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TECHNOLOGY REVIEW

June 1953

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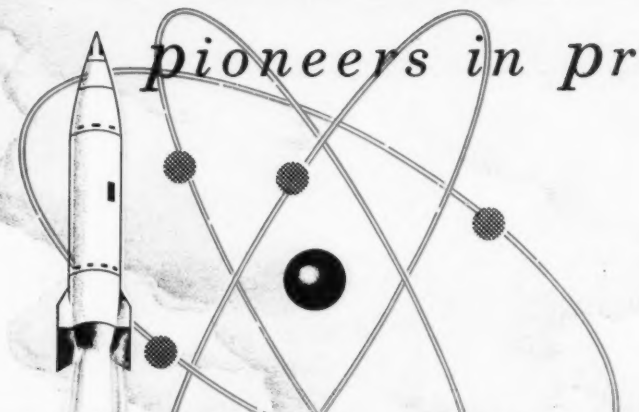

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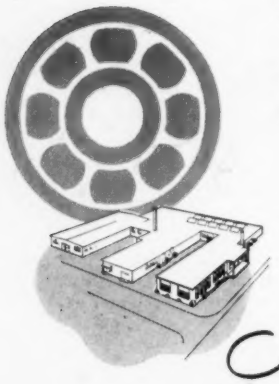

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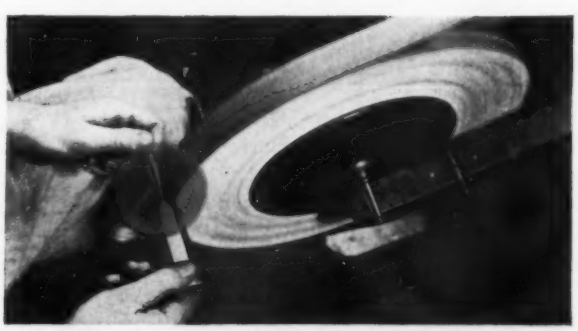

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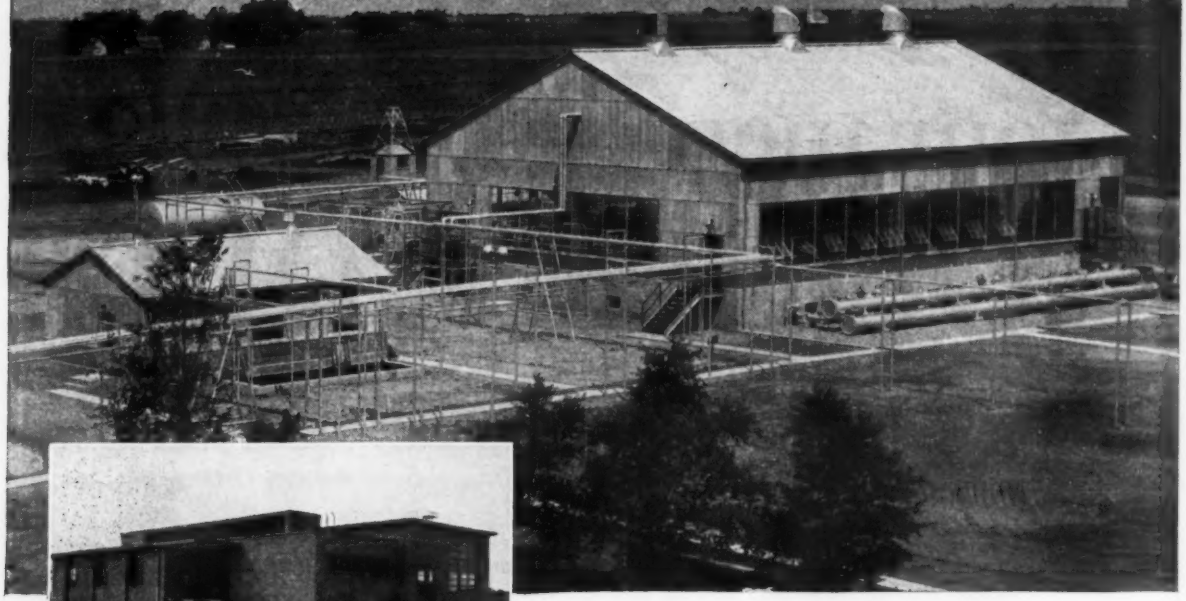

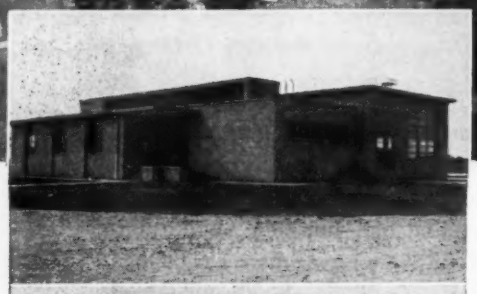

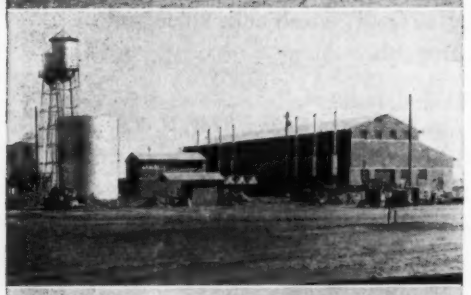

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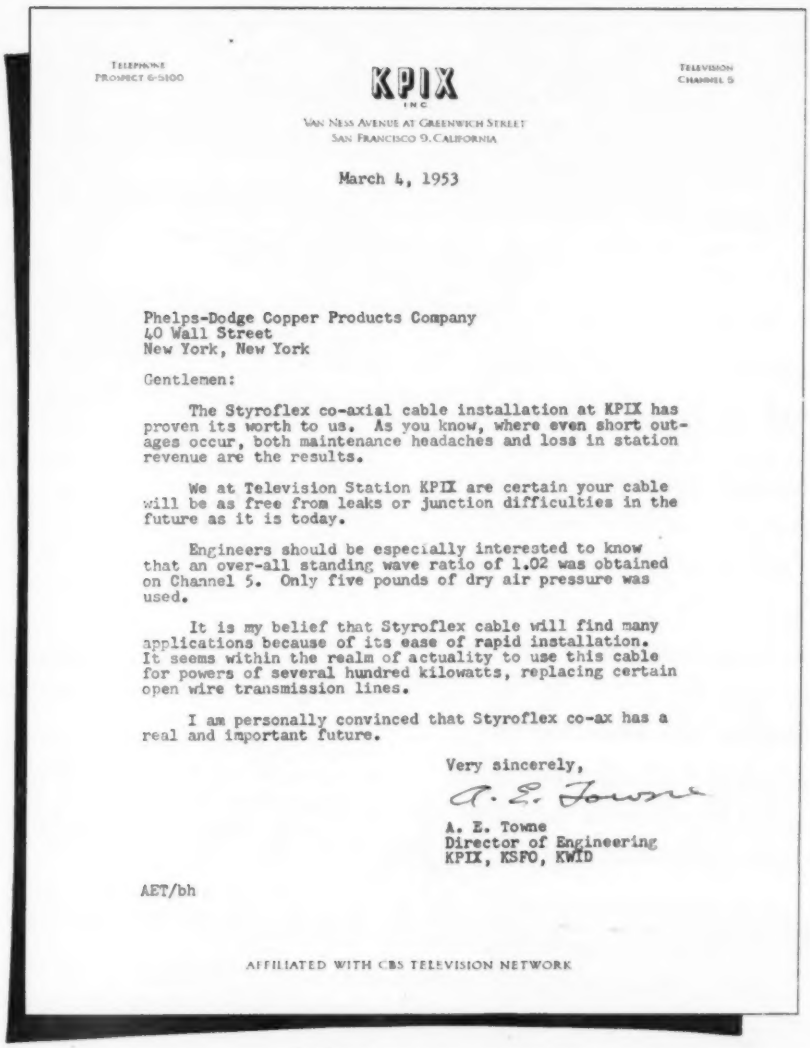

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KPIX
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TELEVISION
CHANNEL 5

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March 4, 1953

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A. E. Towne
Director of Engineering
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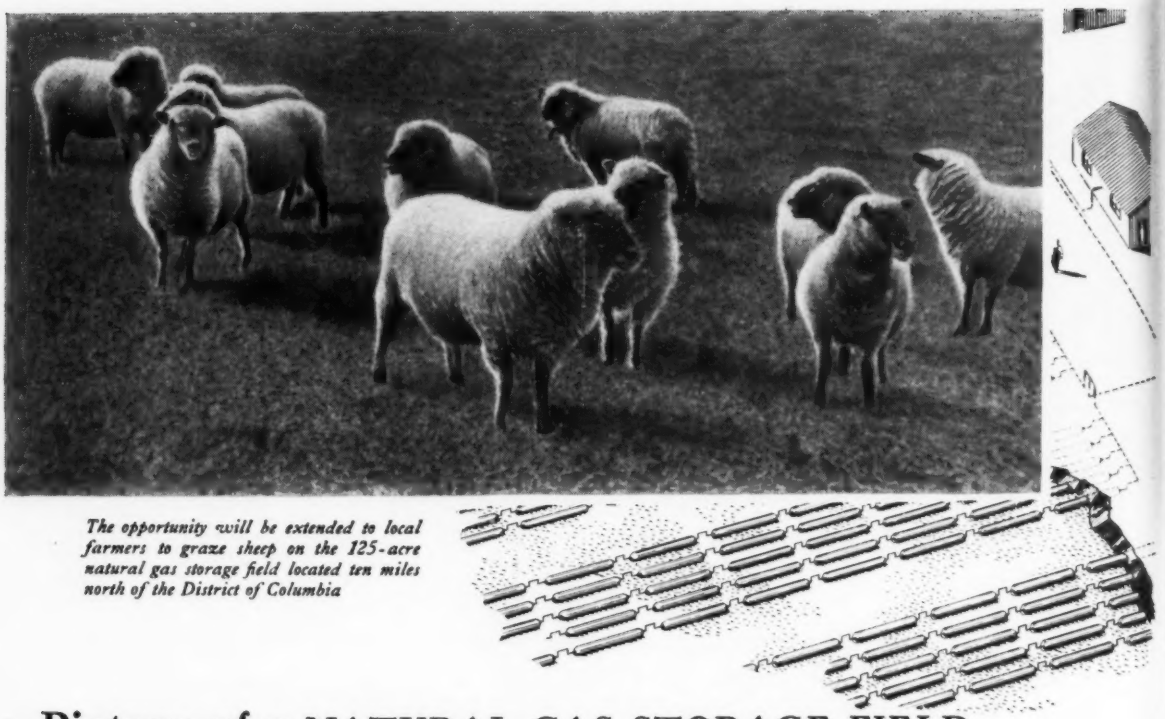

The opportunity will be extended to local farmers to graze sheep on the 125-acre natural gas storage field located ten miles north of the District of Columbia

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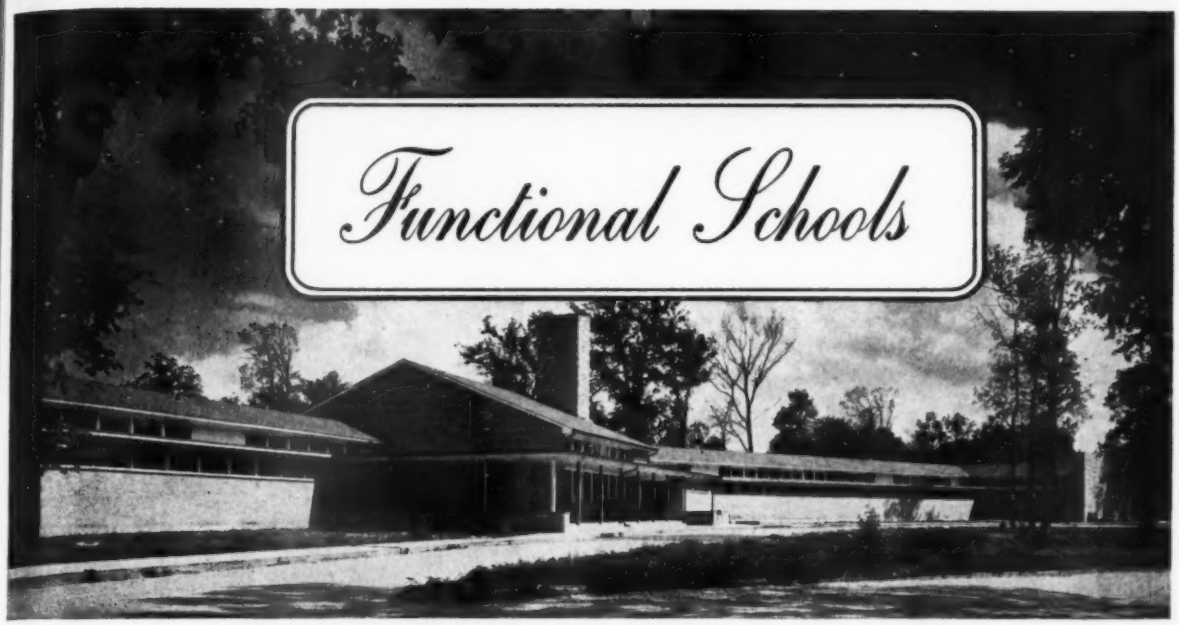

Clyde L. Lyon School, Glenview, Illinois. Walvector in special enclosures along entire walls of windows assures comfort regardless of outside temperatures. Photo by Hedrich-Blessing.

Perkins and Will, nationally known Architects and Engineers, specify "perimeter" heating for comfort and economy . . . .

Many schools designed by this Chicago firm feature large glass areas, for beauty, better vision and more cheerful classrooms. To off-set resulting heating problems, the consulting engineers, E. R. Gritschke and Associates, have specified Webster Walvector Tru-Perimeter Heating for comfort and economy in many of the Perkins and Will schools.

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Left below: Teacher's lounge in Technical Building, Evanston Township High School, Evanston, Illinois. The exposed walls are heated with Webster Walvector painted to match wall color. Photo by Hedrich-Blessing.

Right: Library in Cascades Elementary School, Jackson, Michigan. Auditorium and gymnasium, in separate wings, are available for community use without opening the school proper.

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THE TABULAR VIEW

Industrial Management. — As its first full year of operation draws to a close, E. P. Brooks, '17, Dean of the School of Industrial Management, reviews the hopes, objectives, and accomplishments of the Institute's newest school (page 419). In establishing the School of Industrial Management, Dean Brooks and his associates have aimed to develop future leaders of industry who have a good basic background in science and engineering. Dean Brooks is a graduate of the Institute's Course in Business and Engineering Administration which now forms part of the new School. He has had a distinguished career in business, holding executive positions with American Cotton Oil Company, Montgomery Ward and Company, United States Steel Corporation, and serving Sears Roebuck and Company for a quarter of a century. From 1938 to 1951 he was vice-president in charge of factories, and from 1941 to 1952 was a director of the Chicago mail order firm. From 1949 to 1951, Dean Brooks was chairman of the Committee on Equipment and Materials, National Research and Development Board, and in 1945 was vice-deputy in charge of the American Mission to China for the War Production Board.

Nuisance Electricity. — In the May issue of The Review an article on the "History of Static Electricity" by Sidney M. Edelstein, '32, developed the principal points of progress in early electrical science. Mr. Edelstein concludes his two-part article with a discussion of the role of static electricity in the textile industry, and methods which are being used to combat its annoying characteristics (page 425). That there are problems worthy of any engineer's attention will become evident by Mr. Edelstein's recital of devices which have been used in the past to eliminate static. Mr. Edelstein is technical director of the Dexter Chemical Corporation. He has an extensive personal collection of great works, documents, and letters in the history of science, which has been put to good use in the past few years, in his position as secretary for the Division of History of Chemistry of the American Chemical Society.

Mechanical Resurgence. — The resurgence now taking place in nearly all branches of mechanical engineering is reflected in undergraduate training in this profession. In this issue (page 429) C. Richard Soderberg, '20, Professor of Mechanical Engineering, emphasizes the ways in which an extended program of graduate study, intensive research on problems of real value, and close contact with leaders in industry all act to benefit the undergraduate curriculum in Mechanical Engineering at the Institute. Professor Soderberg was graduated from Sweden's Chalmers Institute of Technology in 1919, and received the honorary degree of doctor of technology from that institution in 1951. He also received the B.S. degree from M.I.T. in 1920. After nearly two decades of engineering work in industry, Professor Soderberg returned to the Institute in 1938 as a member of the Department of Mechanical Engineering. He became head of that Department in 1947.

(*Concluded on page 410*)

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. . . using advanced
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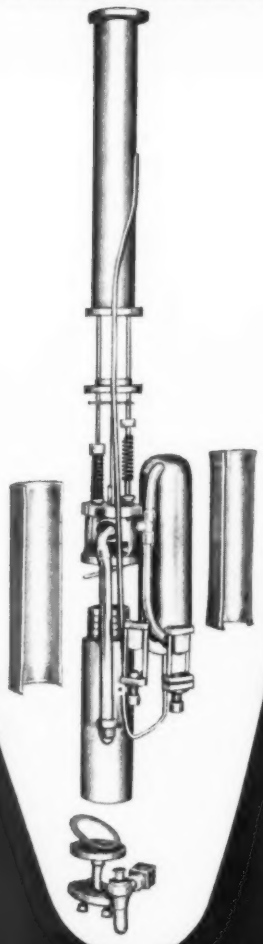

Designing expansion engines for gas liquefaction equipment to operate at *four hundred and fifty degrees below zero* Fahrenheit has its problems — lubrication is just one, contamination and isentropic efficiency, some others. Experience in many areas of engineering metallurgy and physics enabled ADL to design and produce expansion engines which greatly advanced this art.
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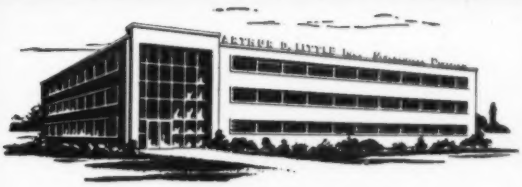

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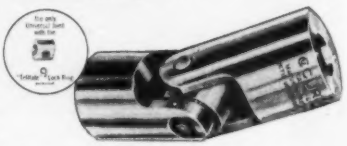

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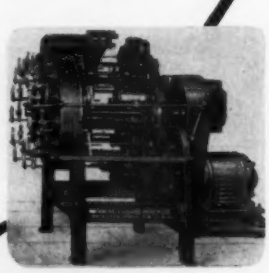

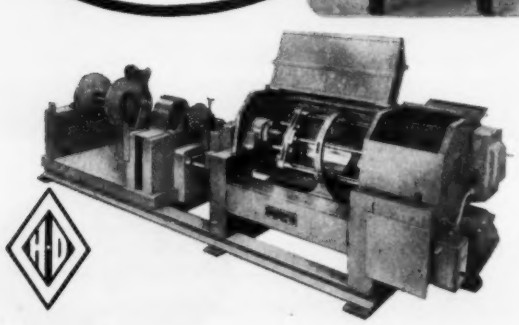

THE TABULAR VIEW

(Concluded from page 408)

Irritating Ionization. — Throughout life, we are all subject to a certain amount of naturally occurring ionizing radiation. Studies which have been made to date indicate that human beings can tolerate, safely, radiation many times that which is encountered naturally. But the sources of radiation-producing mechanisms are ever increasing; radioactive materials are a common commodity in research laboratories, as are various forms of "atom smashers." X-ray machines are used in increasing numbers, and even the cathode-ray tube of television receivers is a potential source of weak x-rays. Hence arises the need to make sure that radiation is maintained at a safe level, as HAROLD BAVLEY is careful to point out (page 433). Mr. Bavley received the B.S. degree from Northeastern University in 1935 and has since been working in the field of industrial hygiene and safety. He is a registered professional engineer, and is in charge of engineering activities of the Massachusetts Division of Occupational Hygiene.

Telling Tales. — For the most part, science has pretty well examined the simple and obvious matters of the physical world. What remains to be done in science is often somewhat remote from the daily life of most citizens. For this reason, modern writers have a difficult task cut out for them when they deal with science, and particularly when they attempt to interpret science in terms of the layman's language. For such writers as these, an understanding of the philosophy of science is of much greater value than a knowledge of the details of the results of a particular piece of research. Such is the view of H. B. PHILLIPS, Professor of Mathematics, Emeritus, whose article appears on page 428. After graduation from Erskine College in 1900, and receiving the Ph.D. degree from Johns Hopkins in 1905, Professor Phillips spent his career in the M.I.T. Department of Mathematics.

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And only the All-Nylon Cord Double Eagle has it!

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If you had been driving the car on the left (and if that screen had been live people), somebody would have been hurt. But the car on the right was equipped with Double Eagles, with the high-traction Resist-a-skid Tread. It stopped in time.

The All-Nylon Cord Double Eagle gives greater safety against blowouts, too. All-Nylon cords make the Double Eagle 1½ to 2 times as strong as premium tires made with standard cords.

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— Woodrow Wilson
(Address of June 14, 1915)

THE TECHNOLOGY REVIEW

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EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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To Technology Alumni

I wish to report to you on the recent testimony of Professors Martin, Amdur, and Levinson, who were subpoenaed to appear before the House Un-American Activities Committee. Let me first quote in full the statement issued by Dr. Compton and myself on April 28:

"The Executive Committee* of the M.I.T. Corporation decided today that Professors Martin, Amdur, and Levinson, who testified freely and co-operatively before the House Un-American Activities Committee, will be continued at the Institute without change of status and in good standing.

"The Executive Committee has examined the present position and recent conduct of the three professors in the light of its long-standing policy with respect to the conduct and responsibility of its Faculty members. The Institute is unequivocally opposed to Communism. It is opposed to regimentation or control which dictates to scholars the opinions they must have and the doctrines they must teach. It believes that the teacher must be diligent and loyal in citizenship and that he must teach in the clear daylight without hidden allegiance or obligations which require him to distort his research or teaching in accord with dictates from without.

"While we in no sense condone the earlier associations with Communism of the three professors, nor would we tolerate the presence of a known Communist on our Faculty, we are convinced that since the true nature of Communism became apparent to them some years ago, they have been free of any sympathy for it and have dissociated themselves completely from it. They have spoken with candor about their past activities, and we are convinced that they are teachers of integrity and loyalty.

"Because of our confidence in them, as well as the candid manner in which they have reported on their past associations, we find no cause to change their status at the Institute.

"This decision of the Executive Committee was reached after a thorough review of the records of the three men and after hearing the report of a Faculty committee which examined the cases."

A copy of the recorded testimony of the three professors may be obtained by those who wish it by writing to the Publications Office at the Institute. Each of the three professors was complimented and thanked by the committee, and to one of them Congressman Clardy said:

"I want to thank you because I think you have done something worth while. I think, speaking for the committee, that we feel you have performed a worth-while service to your government and to this Congress and I trust, sir, that there will be no sanctions imposed upon you because, in my opinion, you do not deserve it. Or, if you find yourself in any trouble or difficulty as the result of your appearance here today, I hope you will communicate with this committee so that we can be of assistance to you."

The name of M.I.T. was also involved in the testimony of Dr. Philip Morrison, Professor of Physics at Cornell. During a sabbatical leave from his institution, Dr. Morrison came to M.I.T. as a Visiting Professor for four months. He is no longer at the Institute. Since he is a staff member of another institution, M.I.T. considered that it had no jurisdiction and that it would be inappropriate for it to comment or act upon his testimony beyond pointing out that it had no knowledge until after he had been subpoenaed that he had been involved in any way in Communism.

*The membership of the Executive Committee is as follows: Messrs. R. H. Blanchard, T. D. Cabot, D. F. Carpenter, K. T. Compton, M. B. Dalton, J. R. Killian, Jr., J. R. Macomber, Redfield Proctor, and J. J. Snyder.

The current investigations of teachers have been met in various ways by American institutions. While it would of course have been better if M.I.T. had not been involved at all, I think that we have nevertheless met the investigations with candor, courage, unity, and patriotism. We have met the issues in the M.I.T. manner. As president of M.I.T., I signed the statement of the Association of American Universities which has received wide approval. Our Faculty, through its committee on responsibilities of faculty members, in representing the faculty point of view, has assumed along with the Executive Committee responsibility for the best interests of the Institute and for the public welfare.

This unity of action is vital because of the nature of a university (which is set forth effectively in the AAU statement). A university is not a "line" organization. "For many reasons," says the report of the AAU, "it must differ from a corporation created for the purpose of producing a salable article for profit. Its internal structure, procedures, and discipline are properly quite different from those of business organizations. It is not so closely integrated and there is no such hierarchy of authority as is appropriate to a business concern; the permanent members of a university are essentially equals."

During the entire period since the close of War War II we have been especially alert for signs of attempted indoctrination of students at the Institute by Communist sympathizers. We have found no evidence of such indoctrination. We have ample evidence that students at M.I.T. are not susceptible to such indoctrination.

We had no grounds for specific action against any faculty member until the disclosures of Herbert Philbrick in 1950, which resulted in the indictment of Professor Struik. We immediately relieved Struik of all Institute duties and placed him on leave pending trial. We had, of course, expected that this case would have been decided in the courts long since. The governing bodies of the Institute are re-examining the case of Professor Struik in the light of the testimony recently presented in Washington.

At the time of the Struik indictment I issued on behalf of the Institute a statement regarding the actions that would be taken in the event that a faculty member was demonstrated to have acted in bad faith or in a dishonest or illegal manner. This statement, which was distributed to Alumni, still stands as a definitive statement of Institute policy. We have consistently been governed by this policy.

The safeguarding of secret information involved in governmental research activities at the Institute has also, of course, been one of our primary concerns. Here we have exercised every precaution, and no evidence has been found of any breach of security.

With these facts before us, I can say to you without reservation that M.I.T. continues to stand firm as a co-operative, unified community of scholars of the highest integrity and loyalty. It continues with pride and diligence to serve our nation and our way of life.

Yours sincerely,

J. R. Killian, Jr.

President

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The Trend of Affairs

Defy the Tooth of Time

In one respect mankind may well envy the rodents, whose front teeth grow continuously throughout life and thus replace wear at the grinding surface. The human being is endowed with but two sets of teeth in the course of his lifetime; and the second of these sets is apt to be quite battered, often gone entirely, before life ends. Human tooth decay – dental caries – has long been the target of intensive research. Some practical advances have been made. In particular it is now known that the regular ingestion during early life of small quantities of the element fluorine, in the form of innocuous salts, will reduce the incidence of dental caries later on. To implement the knowledge, some 150 American communities are now adding small amounts of fluorides to their water supplies – usually about one part fluorides per million parts of water.

But the effectiveness of measures such as fluoridation of drinking water, and the results of long-range dental caries research, all lie in the future. For the present the human chewing apparatus must be patched as fast as it decays. Various materials are used for such patching – the filling of tooth cavities. When the cavity is large, and especially if the grinding surface is extensively involved, an excellent (but expensive) filling is a precision-cast gold inlay. But the majority of fillings are done with substances that can be made up in paste form, that harden after they have been packed into the cavity. Materials of this sort include cements, porcelains, plastics, and amalgams. The latter, popularly called "silver fillings" are very widely used. Their dark color limits them to teeth that usually are not visible; but they have advantages of relative ease of installation, low cost, and durability. A prime virtue of amalgam fillings has been considered to be that, when properly prepared, they expand slightly on hardening, and thus effect a firm bond with the tooth.

The amalgam commonly used by dentists is made just before use, by grinding with a porcelain mortar and pestle five parts of a powdered alloy of silver, tin, copper, and zinc with seven or eight parts of mercury. Excess mercury is next removed by squeezing the plastic mixture between the fingers. The amalgam is then quickly packed into the prepared cavity, the surface is modeled, and the completed filling hardens.

One shortcoming of the amalgam filling has been the critical nature of the packing operation. Degrees of pressure and uniformity of pressure applied during this procedure strongly influence the degree of expansion on hardening and the final strength of the filling. Modern dentists are artists as well as scientists; but the operation of packing amalgam makes heavy demands upon their manual skill.

In an attempt to provide more uniform packing of amalgam fillings, several automatic tamping devices have been developed. Some of these work pneumatically on a compressed air supply; others are mechanical and are contrived to attach to the dentist's regular flexible shaft drilling equipment. The National Bureau of Standards of the United States Department of Commerce recently completed objective tests of amalgam fillings packed with several of the commercially available automatic tampers. Tests of the fillings included measurements of dimensional change on hardening and of compressive strength, and metallographic and chemical analyses. All results were compared with those made on hand-packed amalgams.

The automatically packed amalgams were found not to differ in composition from those packed by hand. The automatically packed fillings appeared to have two advantages: slightly more rapid gain in compressive strength during hardening, and a little greater final strength. They had one possible shortcoming, however; very little expansion or even slight contraction on hardening. Whether this is a practical disadvantage can only be known from actual trials in the mouths of patients.

Acid Polemics

One who has followed newspaper headlines for the past several weeks could easily gain the impression that M.I.T. and the Bureau of Standards have some violent differences of opinion on additive fluids for use in lead-acid storage batteries. If such erroneous impressions have gained ground, they may be attributed to incomplete accounts of political house cleaning in the new administration in which Secretary of Commerce, Sinclair Weeks, asked for the removal of Allen V. Astin, Head of the National Bureau of Standards. Secretary Weeks's action was taken, in part, as the result of the Bureau's investigation of battery additives. Since the Institute's name has figured in this transaction, as an innocent bystander, it may be well to survey the significant points in this program.

During its half century of distinguished service to the nation, the Bureau of Standards has made a careful study of lead acid storage battery behavior and has publicly reported on the effect of material to be added to battery acid to improve performance. When Pioneers, Inc., a West Coast manufacturer began the sale of a battery additive, which it called AD-X2, the Bureau of Standards was asked to evaluate the effects of AD-X2. On the basis of its past studies and the fact that AD-X2 was similar in composition to other additives it had examined, the Bureau of Standards was reluctant to undertake this task. At the request of the Senate's Select Committee on Small Business, the Bureau of Standards did make tests on AD-X2. On the basis of these tests, Pioneers, Inc. was prevented by the Post Office Department from using the mails to sell its product.

In August, 1952, the Select Committee on Small Business requested the Institute to undertake independent tests on the effectiveness of AD-X2. Because such tests would clearly represent routine commercial testing and would not contribute to science, M.I.T. officials were unwilling to undertake this task. The Institute finally agreed to make the required tests, as a public service, at the specific request of the Select Committee on Small Business.

In October, 1952, after the tests had already been initiated, the Institute was advised that no funds were available for paying the costs of materials and man power involved in making the test. The Select Committee on Small Business therefore requested M.I.T. to bear the burden of expenses as a public service. This the Institute agreed to do. Tests were conducted by Harold C. Weber, '18, Professor of Chemical Engineering. In view of the controversial nature of such tests, James A. Beattie, '17, Professor of Physical Chemistry, was asked to observe the experiments and independently verify the facts established, which he did. The results of Dr. Weber's study were also analyzed statistically by George P. Wadsworth, '30, Associate Professor of Mathematics, and Joseph G. Bryan, '38, of the Division of Industrial Coöperation. The studies were completed on December 1, and two copies of the report were transmitted to Blake O'Connor, staff member of the Senate's Select Committee on Small Business, on December 16.

In sending two copies of the report to Mr. O'Connor, the letter of transmittal, written by Julius A. Stratton, '23, Provost and Vice-president of M.I.T., included the following comments:

"I would point out further that there are no recommendations included in this report, nor did our group arrive at any definitive conclusions with respect to the commercial value of the product. The report sets forth the results of very careful laboratory tests, and these results have been corroborated and analyzed statistically."

The report itself stated: "Usually an evaluation of how a product will act under field conditions can be obtained only after extensive laboratory experimentation. Even after such experimentation, it is common practice in engineering work to subject products to field tests. How a given innovation will perform under use conditions is the true test of its worth. For this reason, laboratory findings must be supplemented by field use data if a true evaluation is to be obtained."

In spite of these statements, the M.I.T. report was interpreted as being in conflict with the Bureau of Standards report which did not endorse AD-X2.

When it was announced on April 17 that the functions of the Bureau of Standards were to be reviewed by a distinguished group of scientists representing the National Academy of Sciences and that Dr. Astin would be reinstated, James R. Killian, Jr., '26, President of M.I.T., issued the following statement:

I have just learned of the announcement by Secretary Weeks with respect to the Bureau of Standards and Dr. Astin. Professor Weber, who made the M.I.T. test, and I are delighted by the action taken and believe it particularly appropriate that a committee is to be appointed by the National Academy of Sciences to review the facts in regard to the Battery Additive AD-X2.

Because of the widespread misunderstanding of the significance of the tests conducted by M.I.T., I wish to outline the conditions under which M.I.T. undertook the tests and the implications of the report it presented.

In August, 1952, Professor Harold Weber, a highly competent and experienced professor of engineering at M.I.T., was asked by the Senate Committee on Small Business to advise it in connection with its study of the battery additive AD-X2. Professor Weber agreed to assist, acting with the full knowledge and approval of the Institute.

Last October, the Senate Select Committee on Small Business requested M.I.T. to provide Professor Weber with the facilities to make laboratory tests on the battery additive. It was explained that the committee did not have funds to go to a commercial laboratory. While M.I.T. ordinarily does not carry on such tests, the Institute felt in the public interest it should make its facilities available to the committee. Its purpose in making the tests was not to render a verdict on the product but only to provide additional facts to the government. It would have been inappropriate under the circumstances for M.I.T. to make a decision in regard to the commercial value of the product.

In conducting these tests, Professor Weber served without compensation and M.I.T. made no charge for the use of its facilities. Neither Professor Weber nor any of the staff members who assisted him had any financial interests in this or any similar product or received any fees at any time for the testing of this additive.

The tests were made under Professor Weber's direction as an independent study without reference to earlier investigations, and a report was submitted to the Senate committee in December. He reported that an evaluation

of how the product would act in practical use could be obtained only after more extensive experimentation and after field tests. Thus, Professor Weber reported in effect that from his laboratory tests it was unjustifiable to conclude that the battery additive did or did not have commercial value. His report and that of the Bureau of Standards indicate a difference in judgment as to the conclusiveness of limited laboratory tests. It is not unusual for objective scientific tests to be subject to different interpretations or for differences of opinion to occur in good faith.

At no point in Professor Weber's report is there any criticism of any previous tests on this product, for none was reviewed. The scientific integrity of the Bureau of Standards has never been questioned by M.I.T. or by Professor Weber and they never intended that the report should suggest such a question.

Emission from Single Crystals

ALL of the technology of electronics as we know it today depends upon man's ability to control the flow of electrons in metals and in the vacuum space between metals. Conduction of electricity in vacuum was discovered in 1883 by Edison, when he observed that he could measure a current between a hot filament and another electrode in one of his light bulbs. It was soon found that the current was due to a cloud of electrons coming from the hot filament, and the phenomenon was named thermionic emission. Later workers, notably, O. W. Richardson and R. H. Fowler in England, and Saul Dushman in the United States, attempted to obtain an equation which would correctly relate the current density obtainable from an emitter to its temperature and the amount of energy required to remove an electron (the work function). The relation between current density and temperature is called the Richardson equation. Although it is in qualitative agreement with the results of experiments, Richardson's equation fails to make accurate quantitative predictions of the current to be expected from a real surface. Evidently, the phenomenon was more complicated than the simple assumptions of the theory.

The theory assumes that the emitting surface is uniform and may be characterized by a single value of the work-function. For a while, it seemed that this condition was satisfied when clean, pure metals were used as emitters. However, research carried out in the Physical Electronics Group at M.I.T. in the 1930's indicated that the work function, and hence the emission, differed from one crystal face to the next in the same sample of tungsten used as the emitting surface. Accordingly, one could not hope to get quantitative agreement with the theory for any poly-crystalline emitter where the work-function observed experimentally was some sort of an average over the various work-functions that were present for the surface. Fortunately, there exists a type of drawn tungsten wire, developed for the lighting industry, in which it is possible to grow single crystals extending over the entire wire diameter and up to three or four centimeters in length. The advantage of working with large single crystals, instead of the normal poly-crystalline form of a metal, lies in the fact that some of the surfaces are uniform.

The studies now under way on these single crystals of tungsten involve a number of interesting techniques. As it comes from the manufacturer, tungsten wire, three to five thousandths of an inch in diameter, has a surface that is very deeply scarred when viewed under an optical microscope. The deep scratches left by the dies through which the wire has been drawn must be removed by grinding away the adjacent regions, and the wire must be polished until it appears as a very shiny metal cylinder under high magnification. The grinding and polishing operation may take as long as several full days and is accomplished by using an automatic wire-polishing lathe developed in this laboratory. The polished wire is placed on the axis of a cylinder vacuum tube in which it is heated by the passage of current. If the wire is heated for many hours at a temperature of about 2,300 degrees C. some of the small crystal grains grow at the expense of their neighbors, with the result that large single crystals are formed.

Once a satisfactory crystal has been observed, it is removed from the tube in which it was grown. Its diameter is measured to a ten-millionth of an inch by using the wire to form a wedge of air between two optical glass flats and counting the number of interference lines produced. The temperature of the wire during the experiment can then be obtained from this value of the diameter and the magnitude of the heating current.

To determine the energies of electrons emitted in the different crystallographic directions, the crystal is then placed in the magnetic velocity analyzer tube. In this tube, the emitted electrons from one crystallographic direction are focused by an electron lens upon the entrance slit of a metal chamber. Through the action of an externally imposed magnetic field, electrons possessing just the right amount of kinetic energy travel in circular trajectories in this chamber and are collected as they leave an exit slit. Comparisons can then be made between the energies of electrons emitted in the various crystallographic directions. Since the magnetic fields used for the measurements are quite low, it is necessary to neutralize the earth's field to within one tenth of one per cent in the neighborhood of the tube. Accurate temperature control of the crystal is maintained by monitoring a series-connected auxiliary filament with a phototube. During the measurements, the crystal is maintained at the desired temperature by pulses of heating current at 1,000 cycles per second.

It is expected that the information obtainable from detailed studies of the emission process will be of value in interpreting the behavior of more complex emitting surfaces. It should also enable us to gain a clearer picture of the electrical properties of material surfaces which play important roles in transistors as well as vacuum tubes.

The work reported here is being carried out by Andrew R. Hutson, research assistant in physics, in the Physical Electronics Group of the Research Laboratory of Electronics, under the direction of Professor Wayne B. Nottingham of the Department of Physics. Related studies on field emission from points are being conducted by John M. Houston, research assistant in the Department of Physics.

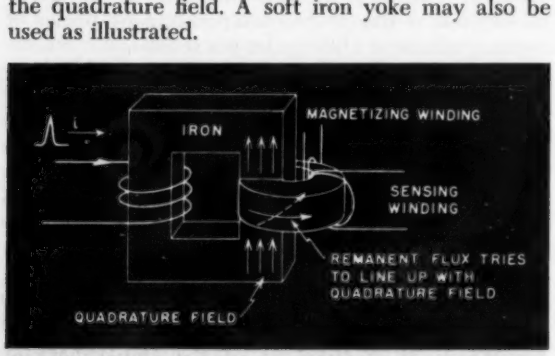
Sensing of Magnetic Cores

THE modern high-speed digital computer is built up largely of electrical devices which have two stable states or conditions very much like the on-off states of a common toggle switch. Small ferromagnetic cores can be used to store binary information through their ability to hold, or "remember," the direction in which they have been magnetized. The "memory flux" may be switched fairly rapidly from one stable state to the other. Heretofore the general method for determining, or sensing, the stored information has required switching this flux which destroys the information. There has been no quick and easy way of sensing without at the same time erasing and having to take the time and trouble necessary to re-store the information. This difficulty has now been overcome as a result of research conducted in the Institute's Digital Computer Laboratory by Dudley A. Buck, '52, research assistant, and Werner I. Frank, '53.

A "non-destructive" method of determining the direction of magnetization is under development which allows the core to be sensed any number of times without losing its information. A very short pulse of electrical current establishes a magnetic field at right angles to the memory flux. This quadrature field causes a voltage pulse to be induced in one of the conventional windings on the core; the polarity of this pulse indicates direction of the memory flux.

The operation of the new sensing scheme can be described as follows: When the quadrature field is applied, the memory flux is rotated a few degrees, from one of the two conventional memory directions, to result in a sudden decrease in the component of the memory flux which links a conventional output winding. The decrease in flux induces a voltage pulse in that winding, the polarity of which depends on whether positive or negative memory flux has been decreased. That is, the output voltage pulse is positive for one information state and negative for the other. When the quadrature field is turned off, the memory flux returns to its original direction because of the nature of the material used for memory cores which exhibits a rectangular hysteresis-loop.

Many techniques can be used to obtain the quadrature field. With metallic ribbon-wound cores, a current pulse sent directly through the ribbon produces the quadrature field. A soft iron yoke may also be used as illustrated.



A pulse of current flowing through a winding on the rectangular iron core generates a voltage pulse in the sensing winding, which is used to determine the direction of magnetization of the toroidal memory core.

Oil from Mathematics

THE increasing amount of petroleum to serve the world's industrial needs has already caused many oil fields to become exhausted, and has made the work of the prospector increasingly difficult. Temporary relief from the constantly pressing needs for more oil was afforded, about two decades ago, when the reflection seismic method of petroleum prospecting was put into general use.

In the past few years the search for new oil has required the investigation of areas in which petroleum reserves are increasingly difficult to locate. Present-day techniques, in which the geophysicist examines seismograms visually, are reaching the limit of effectiveness for these areas. If new oil fields are to be discovered and worked economically, improvements in prospecting techniques must be continually introduced. Perhaps the greatest step forward, in the immediate future, may be achieved by more penetrating methods of analyzing seismograms, through the use of statistical techniques in which modern high-speed computers may play a significant role. The application of modern statistical methods makes it possible to separate the desired energy reflections from extraneous variations on seismic records, so that more of the information obtained in the field may be put to practical use.

Research on this problem is being carried out in the Department of Geology and Geophysics at the Institute under the direction of a staff committee, with Enders A. Robinson, research assistant, in charge of operations. The project was initiated by George P. Wadsworth, Associate Professor of Mathematics.

By applying appropriate averaging techniques to different sections of reflection seismograms, it was found that the dynamic characteristics remained fairly consistent except during intervals corresponding to a reflection. The inconsistency, or error, introduced gives a measure of the change in the dynamic properties, and hence may be used as an indication of the amount of energy reflected. By examining an error plot, derived from the original seismic record, one is able to pick off the arrival of reflected energy at places of high error. More directly, one may correlate places of high error with interfaces between sub-surface layers. Thus, such an error plot becomes a more powerful tool than the original seismogram in determining the underground structure of the earth, and consequently increases the likelihood of success before actually drilling a well.

For the seismograms thus far analyzed, results to date have indicated that the new method of analysis yields valid error plots. Moreover, such a method may even differentiate zones of greater scattering which have no single major reflecting surface. In addition, the work has yielded valuable information on the dynamic characteristics of recorded earth movements, and may also form the basis of a considerable amount of theoretical work of value to geologists.

An open invitation to petroleum companies to collaborate in this research program has resulted in both financial support and close scientific liaison between the research group at M.I.T. and the research organizations of petroleum companies.

M.I.T. Photo
Latest addition to the Institute's academic buildings is this handsome structure which houses the School of Industrial Management.

The School of Industrial Management

A Progress Report on the Institute's Program to Combine Education for Management with Basic Training in Science and Engineering

By E. P. BROOKS

In 1951 and 1952, the Institute was the scene of significant developments in the field of education for management. Grants in excess of $6,000,000 were made to M.I.T. by the Alfred P. Sloan Foundation, Inc., to establish a School of Industrial Management and to provide for research activities at the new School. These gifts brought to M.I.T. an extraordinary opportunity for greater service in the field of business management by making possible improved physical facilities, an enlarged Faculty, and important research resources. Included in these gifts was a grant of $1,000,000 which provided for the establishment of the Sloan Research Fund. The Fund was to be used to expand basic knowledge in the field of industrial management and to round out the teaching program of the School. Spotlighted in these developments was the Institute's long established Course XV in Business and Engineering Administration, which became the undergraduate program in the School and whose faculty became the nucleus around which the School would be developed.

The establishment of the School of Industrial Management began a search for ideas – old ideas, new ideas, better ideas – on how to organize and develop a school for industrial management. Out of this reconnaissance of the past year or more have come certain ideas which we, in the School, believe to be basic in the development of our program. Not all of these ideas are new, nor are they all that will be developed as the School grows. Some of them involve a new emphasis and some are reaffirmations of faith. They are all the result of slow and painstaking efforts to avoid duplicating existing schools of business; in short, they represent continuing efforts to find a better approach to management education than has been evolved thus far.

There should be little doubt about the controlling ideas that have shaped the School of Industrial Management. At M.I.T., the business of laying a groundwork for accumulating management experience has long been an integral part of the Institute's teaching activities. As early as 1914, M.I.T. pioneered in or-

An atmosphere of friendly informality characterizes a conference on the School's educational program. In usual reading order are Eli Shapiro, Professor of Finance; Douglas V. Brown, Alfred P. Sloan Professor of Industrial Management; Edward P. Brooks, '17, Dean of the School of Industrial Management; Ronald H. Robnett, Professor of Accounting and Associate Dean; and Erwin H. Schell, '12, Professor of Industrial Management.

M.I.T. Photo

ganizing an undergraduate curriculum combining management and engineering education. Since then, nearly one-eighth of the undergraduate degrees granted by the Institute have been awarded to men who have taken the program in Business and Engineering Administration. In 1925, this plan of education was broadened to include an advanced curriculum in business management for graduates in science and engineering; and a program of executive development for men of about ten years' industrial experience was begun in 1931.

Over the years, the achievements in management of the men who have had this type of education present a strong case for believing that the original idea has never lost its vitality. Not only is it apparent that the successful management of industrial enterprises demands ability to cope with technological problems of ever-increasing intensity, but it is believed from experience that fundamental training in science and engineering develops habits of precise thinking which are essential in the study and practice of all aspects of industrial management. Accordingly, the form and content of the curricula have evolved as the frontiers of knowledge have grown and as industry has become more complex. But, the original purpose – to combine education for management with basic training in science and engineering – has remained unchanged.

Today, it is possible to argue that this plan of education serves a need far greater than ever before in its nearly 40-year history. With the increased size and technical nature of business enterprise, industrial management must increasingly represent a union of scientific knowledge and the entrepreneurial skill and inventiveness to apply that knowledge. Industry's drive for increased productivity has resulted in highly special skills and expensive machinery designed in many cases for unbelievably narrow purposes. Business units themselves have become a composite of distinct, though interrelated, specialties – for example, production, finance, accounting, and distribution. Everywhere, specialization and interdependence are the order of the day.

All this may be well and good for enhancing productivity but, somewhere along the line, management is faced with making decisions affecting not one or perhaps two, but all aspects of a business. Interestingly enough, management can neither afford to do its thinking by piecemeal nor in separate compartments. Nor, for that matter, can it successfully make decisions without regard to the total of economic and social factors likely to affect the outcome of a particular business decision.

Successful management does its thinking in broad sweeps. But doing so requires a firm understanding of what goes on inside and outside a particular business. Contrary to popular belief, decision making in industry is not a chess game whose outcome depends upon hunches or crystal ball gazing. Rather, the success or failure of business judgment has come to depend largely upon the ability of management to assemble facts and to appraise the relationship between separate pieces of information and the particular problem at hand. Indeed, industrial management has become a creative study which calls for a breadth of understanding and precise habits of thought.

It is this need for broad understanding and disciplined thinking by tomorrow's business leaders that determines the outlook of the School of Industrial Management. Broadly stated, the purposes of the School are: (1) to discover means of increasing the effectiveness of industrial management and to disseminate this knowledge; and (2) to assist young men to fit themselves for future positions of business leadership. These ends, which are necessarily inseparable, are of course shared by other educational institutions. However, as an integral part of M.I.T., the School is in a unique position to promote these objectives by blending science and engineering knowledge with administrative skill.

Herbert F. Goodwin, '37, Assistant Professor of Production Management, conducts a graduate seminar in production management. Close student-faculty relations are facilitated by small classes of carefully chosen students. An awareness of the realities of business are part of the broad education for management which students receive in an environment in which science and engineering play a significant role.

M.I.T. Photo

The School aims to teach a limited number of selected young men in such a way as to contribute, as best it can, to their ultimate success in top-level management of industry. In setting this high aim, the School entertains no illusions about what it can do and what it should not attempt. Experience and constant review have led to the conviction that education for management must be a *joint undertaking* – a partnership, as it were, between industry and schools for management.

But the partnership also requires a division of labor. Industry must provide the environment and the experience required for management leadership; schools for management must lay the foundation for that experience. Chronologically, this division of labor makes sense. In terms of the equipment available to industry and to educators, the case for this joint enterprise is even clearer.

The School recognizes that industry is better equipped to train its own management specialists on a job experience basis. Therefore, the development of management specialists is not the purpose of the School nor is specific job preparation a part of its curriculum. What industry frequently cannot do, however, is to give its potential leaders the kind of fundamental education which deals with all aspects of a business but which cannot be gained by extensive experience in one or two management functions. The School regards this need for fundamentals as its maximum opportunity to render service to industry and to its students. Thus, it seeks to train managers rather than technical specialists, to develop "statesmen rather than experts."

There are two undergraduate programs in the School of Industrial Management, identical in their business and humanities content but differing in respect to science and engineering subject matter. In these four-year programs, slightly more than one-half of the student's time is occupied with engineering and scientific studies, 30 per cent of his time is devoted to management studies. His remaining time is devoted to studies dealing with the relationship of industry to society – economic, historic, and social – and man's relationship to man. This is an important contribution of the School of Humanities and Social Studies. Course XV-A is based on the physical sciences and XV-B on the chemical sciences; both lead to the degree of bachelor of science. Together, these undergraduate programs contain the bulk of the School's students and constitute the major teaching emphasis.

The program of business subjects begins in the sophomore year with a two-term introduction to the nature of modern business and its management problems. This introduction is followed in the junior year by five required one-term subjects, each dealing with a major functional area of business management, emphasis being placed on an increasing depth of understanding of business problems and on the acquisition of a working knowledge of important managerial tools and techniques. Subjects in accounting, finance, marketing, production and personnel administration are presented from the standpoint of familiarizing students with the usefulness and limitations of these fields as tools for management. In each field, descriptive material is kept at a necessary minimum while heavy stress is laid upon problem detection and analysis. Students are required to demonstrate their ability to deal effectively with these fields by frequent oral and written reports of case situations.

In the senior year, opportunity is afforded for selection, with the aid and advice of the faculty, of from three to five one-term subjects compatible with the interests and aptitudes of the individual student. In this year the range of electives is such that the student may both broaden his knowledge by the study of new areas, and increase his depth of understanding by doing more advanced work in one or more subjects with which he already has some familiarity. An important part of the fourth-year program

is the thesis, which affords the dual opportunity of exploring in depth a problem of the student's own choice and of carrying out a limited research program on his own initiative.

There are practical limitations on the School's ability to carry out the M.I.T. philosophy of "learning by doing"; our laboratory stretches the length and breadth of American industry. There are, however, a number of reasonably effective ways to bring students into contact with industry, directly or indirectly. The faculty of the School includes a number of persons of extensive industrial experience, and close contact with business is maintained by most of the faculty through consulting activities. Close student-faculty relationships permit the student body to benefit from this experience through small discussion sections and individual counsel on thesis and other research projects. Case studies are used, where appropriate, to bring reality into classroom situations. In addition, many visiting teachers and lecturers from industry come to the School, and there are frequent student visits to commercial and industrial establishments. Student theses normally involve the analysis of actual problems in the field and thus bring students into working relationships with business concerns. By the end of the senior year, students are expected to have a keen awareness of the realities of business as well as an independence of thought which should enable them to take an open-minded and informed approach to practical problems.

The School also has a graduate program which serves recent college graduates in science or engineering through its curriculum leading to the degree of master of science in Industrial Management. The graduate program normally requires two years for those who have had no previous work in this field. Those who have completed the School's undergraduate Course in Business and Engineering Administration, or who have done substantially equivalent work elsewhere, normally obtain the degree in one year. The graduate student body is small, and, relative to staff, will continue to be so. Standards for admission are high, and every effort is made to choose those men who show the greatest potential for future leadership of industry. Much of what the individual learns from his formal education, particularly at the graduate level, is dependent upon the interchange of ideas with his classmates. For its part, the School recognizes that selection is probably the most important single determinant of the effectiveness of graduate education. Hence, the advantages of careful selection are believed to be substantial. The problem of selection, both for management education and for executive positions in industry, is one of particular interest to the faculty and is the subject of continuing study in the School.

Recent expansion has brought the total graduate enrollment, including the Executive Development Program, to just under 50 students. Next year this number will be substantially expanded by (1) admission of more students in the one and two-year graduate programs; and (2) the addition of more Sloan Fellowships in the Executive Development Program.

The Sloan Fellowships are designed for men already holding responsible positions in industry; participants are selected on a nationwide basis from among candidates nominated by employers. These men must have a minimum of five years of industrial experience, have demonstrated aptitude for growth in management, and preferably, have a background in science and engineering. A special 12-month curriculum is designed to prepare them for dealing effectively with the broader and longer-term administrative problems that will be encountered as they assume higher executive responsibilities. While the subject matter dealt with by the Sloan Fellows to some extent parallels that of the regular graduate program, every effort is made to capitalize fully on the maturity and background of the group. As a result, an unusual breadth of understanding of

Active participation in discussion of the problems of industrial management typifies work in the School of Industrial Management. Here a group of students in the management laboratory discuss a student project.

M.I.T. Photo

The Sloan Executive Development Program is an important phase of work in the School of Industrial Management. Gerald B. Tallman (left) discusses the Sloan Program with Thornton A. Wilson and Wayne L. Horvitz.

M.I.T. Photo

economic and administrative problems is gained by the Sloan Fellows while, at the same time, the regular graduate students have the opportunity for extended contact with experienced men of unusually high caliber.

Continuing research on the problem of executive development has indicated that there is an additional demand for the School's services in programs of shorter length than the Executive Development Program. Many companies, particularly smaller companies, are unable to release qualified executives for a full year's advanced study at M.I.T. However, they have indicated a strong desire to participate in shorter-length programs, tailor-made to fill specific gaps in their own executive development activities.

To serve this need, plans are being laid for short, special purpose workshops designed to give participating executives a knowledge of specific managerial tools with which they have had little or no experience. This summer, the first of these programs will be held at the School – on an experimental basis. For its content, it will concentrate on Control Problems of the Executive, with special emphasis on the accounting function and accounting controls. Experimentally, it will serve as a pilot study of the abbreviated type executive development program as an aid to future planning.

Behind each of the programs described above is the all-important element of the School of Industrial Management – its faculty. Fine buildings, classroom equipment, and other facilities go for naught unless there are capable teachers to interpret principles and ideas, and to inspire students with an over-all understanding. In this regard, the School is fortunate to have started off with a corps of experienced and capable teachers. Not only have they vastly simplified the School's organizational problems, but in their hands rests the School's chief capacity for further growth.

We, in the School of Industrial Management, take a large measure of confidence from the leadership of Professor Erwin H. Schell, '12, who continues in charge of the undergraduate Course in Business and Engineering Administration and who has been the chief architect of that Course throughout much of its existence. To his students, to the Alumni of Course XV, and to those of us at M.I.T. who have had the benefit of his acumen and inspired teaching, his presence alone insures that no stones are being left unturned in the course of developing the School to meet its objectives.

Our most pressing problems are, of course, growing pains. In developing the new School and in selecting its faculty, we have sought to avoid duplication of existing schools of business. Repeating the old established patterns would have been the fast and easy way to start the School; we have chosen the slower, more difficult path of re-examining the premises of management education and of seeking a fresh approach.

We have taken a hard look at the unresolved problems facing the schools of business in the United States. Measured against the performance of schools in other fields in this country, the comparison has not been favorable; indeed, much remains to be done. In general, we have found that there is a feeling that schools of business, many of which started some 30 to 40 years ago with a great deal of promise, have somehow not measured up to all that was expected of them. Certainly, our schools of business have not distinguished themselves in their field as have our engineering schools, law schools, and med-

ical schools in their respective fields. The business schools are, of course, younger, but the concern about them has had to do with their basic programs, not with their inexperience.

Our reconnaissance so far has led to the conclusion that if the School of Industrial Management is to move toward its objectives, it will do so, not by a percentage improvement in this activity or a percentage improvement in that activity, but rather from a better approach – a better understanding of what management is and what training for it should be. To this end, our search for a better approach has been a continuing search, not merely a build-up to a once-and-for-all improvement or even to a periodic improvement, but the beginning of a continuous review and experiment.

The School does not presume to know the detailed steps it should take to realize its broader objectives. Far from this, its method of attack has centered on the principle of gathering advice from every available quarter. In our search for enlightened counsel, we have exploited every opportunity to learn by inviting comment from within and outside the School on every phase of its activities. An Advisory Council consisting of 25 leaders of American industry has been created under the chairmanship of Alfred P. Sloan Jr., '95. By acting as a sounding board for new ideas and by generating important ideas of its own, the individual members of the Council serve a double purpose. In other instances, the members have constituted an indispensable link between the School of Industrial Management and the business community.

"Task forces" have been appointed to report on specific questions growing out of the School's increased use of the many resources at the Institute and its further integration with the business community. These task forces have consisted of teams of educators and industrial leaders working together in some cases and alone in others, according to the particular assignment. An example of this work is the report by a committee of faculty members in the School of Humanities and Social Studies. The subject of their study has been "The Place of the Social Sciences in the School of Industrial Management." Another example, involving a mixed group representing educational and industrial fields is the report of the task force on marketing. The question before this group was: "What role should marketing and distribution play in the curriculum and research activities of the School?" Another team is studying the relationship of the School to the business community – and the list goes on.

As each report has materialized, it has been subjected to the give and take of faculty meetings and more faculty meetings. The upshot is that we have found it possible already to incorporate some of these constructive ideas into the School's various curricula for 1952–1953.

Not all of the recommendations brought to the School or originated internally have been entirely usable or completely new. But each has required, and has received, an evaluation of its own. Fortunately, we have been kept from chewing over too many old bones by the accumulated experience of the Department of Business and Engineering Administration. By building around the nucleus of knowledge already at its disposal, the School has been able to focus its efforts almost entirely upon growth and development.

We have also had growing pains of another kind – the usual problems associated with adjustments in size and structure. While we have expanded the School's several parts across-the-board, our growth has not been uniform in each part. Even if it were desirable, not all of the School's activities are capable of uniform expansion immediately. For example, the expansion of educational services can be effected more rapidly than that of research in the management field. Through improved physical facilities and an enlarged faculty, the School is now ready to accommodate a larger number of students in its undergraduate and graduate teaching programs. But – research is another matter. Full benefits of research – to the School and to the business community – must necessarily await the passage of more time. This much is clear from the several projects already authorized and in progress under the Sloan Research Fund.

To sum up, our growing pains are real in the following sense: As we have reached out to meet our enlarged opportunities to serve, we have found problems commensurate with our new responsibilities. More than this, we have encountered the normal stresses and strains of a going concern growing unevenly in its several parts.

In this connection it is particularly enjoyable to review the widespread interest directed toward the growth and development of the School in the past year or more. Busy men in industry have shown an inspiring willingness to make serious and time-consuming contributions to the welfare of the School, unrestrained in many cases by their own heavy workloads. We are grateful to our Alumni of the Course in Business and Engineering Administration who have taken an active part in supporting the expanded operations of Course XV and in making valuable suggestions for charting the future course of the new School. We are indebted to the companies and other friends of the Institute who have already given generous assistance to the School's desire for closer association with the business community. An equal debt is owed to our colleagues at the Institute upon whom we have placed increased demands for science, engineering, and humanities education through our increased emphasis on fundamentals of technology.

Indeed, it is difficult to ask for more favorable working conditions than those afforded by the M.I.T. environment. As one part of an expanding galaxy, the School of Industrial Management should find it easier to utilize the facilities already existing at the Institute as well as those inherent in the Institute's indicated pattern of growth. Certainly, the opportunity to grow as M.I.T. grows should provide an additional stimulus to the School to educate men for the continuing advance of the American productive genius and our understanding of the system which underlies this progress.

Electricity in the Textile Industry

Major Problem in Textile Manufacturing Is That of Eliminating Electrical Charges on Fabrics

By SIDNEY M. EDELSTEIN

Part I of Mr. Edelstein's article, on the historical background of static electricity and the discoverers in this field of science, appeared in the May issue of The Review. Part II, presented below, discusses the problems of static electricity in the textile industry.

THE dawn of the Nineteenth Century marks the beginning of the industrial revolution, and a new dynamic age in man's life and thought. The first year of the Nineteenth Century also marks the dynamic age in electricity, for on March 20, 1800, Alessandro Volta sent a letter containing the first description of his "electrical battery" to the president of the Royal Society.*[19] The interest of the scientific world in static electricity almost immediately disappeared and was transferred to electricity in motion – the power of which has so transformed our world. Almost 150 years were to pass before a revival of interest in the study of static electricity took place.

Today, the revival of interest in the science of static electricity is due mainly to the textile industry. The recent introduction of many new fibers which are strong static producers has posed problems for the manufacturer and consumer of these new textiles. The solution of these problems can be made by the application of scientific principles described long ago, coupled with our modern knowledge, in many new fields. Many of these old principles are apparently being rediscovered by workers who have not realized that the ground was covered thoroughly years ago.

How Static Develops in Textile Materials

Although the fundamental explanation as to how static can be generated in nonconductors is quite complex, in textiles there are only three mechanisms of importance.

The first important mechanism is double layer separation. When any two neutral dissimilar substances are brought into contact, electric charges occur in pairs of positive and negative kinds. Negative charges, that is to say electrons, migrate to one substance making that substance negatively charged; whereas the other substance having lost electrons becomes positively charged. Now, the positive charges on the one substance are exactly equal and balance the negative charges on the other substance. The number of charges developed in the substances depend on the chemical nature of the substances, the extent of area in actual contact, and the pressure between the two substances. We only become aware of the presence of these charges when the substances are separated. For then, if one substance is a nonconductor, such as a textile fiber, the charges which it held become entrapped and the fiber becomes negatively or positively charged. If the other substance is a conductor, then its charges are almost immediately dissipated and this substance becomes neutral. If the second substance however is also a nonconductor, it then shows a charge on separation from the textile fiber – equal, but opposite to, that on the fiber.

The second important mechanism for the generation of static electricity is friction. If two neutral dissimilar substances are rubbed together, the negative charges are rubbed off one substance and taken up by the other. Upon separating the two substances after rubbing, the nonconductor, or textile fiber, entraps its charges and becomes either positively or negatively charged. If the other material is also a nonconductor, it will have an equal but opposite charge.

Now, there is a question among scientists as to whether the mechanism for forming static electricity by friction is really different from the double layer mechanism. Some think that friction simply promotes closer contact between the two surfaces. Others believe that there is some fundamental effect caused by friction which is in addition to the effect caused by just contact of the surfaces.

The third mechanism is important only in special cases. In a flame, lighter or more diffusible particles of carbon and other substances will have a charge opposite to that of the heavier particles. When a nonconductor, such as a textile, is held close to a flame, the heavy charged particles tend to attach themselves to the textile, and the textile becomes charged, or in other words develops static electricity.

Now, with an understanding of the mechanisms whereby static electricity may be generated in a nonconductor, such as a textile fiber, it becomes easy to visualize how such generation may take place in blending, spinning, weaving, drying, and also in the use and wear of a fabric. In other words, at every point where a textile touches another substance, static electricity must be generated. Static may not be enough to reveal itself, but it's there potentially.

Troubles Caused by Static in Textile Manufacture

The effects of static electricity in the processing and manufacture of textiles are mostly undesirable effects. How undesirable these effects are will depend on

* Please see references on page 427.

Ewing Galloway, N.Y.
A detailed study of a modern worsted warping machine

many factors; one of the most important factors being the chemical nature of the fiber. As our fibers become more nonconducting, and as they become less moisture absorbing, each potential source of trouble due to static becomes greater. That is why, when we deal with the new synthetic fibers, every potential source of trouble from static becomes an actual source of trouble unless we take special steps to control the static. In the case of the natural fibers, such as cotton and wool, many of the potential sources of trouble never actually break out into real trouble spots, but when conditions are right, trouble will be there.

Recently a writer has pointed out that static electricity could cause four major problems in textile manufacturing, and these are:[20]

1. Reduction of output
2. Lowering of quality
3. Increase in waste
4. Hazards to personnel

These four major problems are potentially present in most textile operations. They may exist in the blending and carding down through the drawing, sizing, knitting or weaving, and even in the final operation of inspection and packing. The potential troubles due to static in textile manufacturing are almost endless in number. As we increase our operating speeds, and particularly as we use more and more of the new synthetic fibers, these potential troubles will become real ones.

How Static Electricity in Textiles Affects the Consumer

The effects of static electricity for the consumer run the whole gamut from the commonplace to the unusual.

Perhaps one of the most unusual cases was that recently reported by one of the large department stores, wherein they cheerfully refunded the money to a lady who had purchased a blanket made of one of the new acrylic fibers. She was fond of listening to the radio in bed, snuggled up warm within the blanket. Everytime she moved, static electricity was generated within the blanket and spoiled her radio reception, at least so she said. Unquestionably, the public has really become conscious of the static problem in the newer fibers.

Another static story is that reported by a men's wear store of a customer who had bought a suit specially made of one of the new synthetics for summer wear, when conditions for static generation are at their poorest. This particular customer had chosen to wear the suit, however, on a cool, dry fall day. The store reported that the gentleman came running into the store shouting, "get it off; get it off." The suit was clinging and twisting around him like some evil spirit. Of course, all that would have been needed to complete the picture would have been a discharge of St. Elmo's fire from the man's head, and this would have given emphasis to a report that a man from another planet had landed from a flying saucer.

Now, most of the consumer problems due to static are much less exciting, and not too spectacular, but they are very important, nevertheless. Some have been with us for a long time, such as the shock we often get from a carpet on a cool, dry day. But of course, the static problem from the consumer point of view has only become acute with the widespread use of the synthetic fibers which began with the use of nylon, and more recently with the employment of vinyon, dacron, orlon, dynel and the other fibers based on synthetic plastic materials. These problems fall into certain distinct groups, which are common to all the fibers.

First, there is the effect of static electricity in causing clothing to cling to the body under certain conditions, or to be repelled from the body under others. The important draping qualities and appearance of the fabric, or garment, are often completely ruined by the effect of static. The uncomfortable feeling to the wearer of the garment is obvious.

Unfortunately, a textile charged with static electricity has the power of attracting uncharged particles. Therefore, the static problem in the new synthetics has added the problem of dirt attraction. This is not only a problem for the store in displaying an article made of one of the new synthetics but it is certainly an unpleasant condition for the consumer who buys a suit made of a new synthetic fiber because of its stain-resisting properties only to find that his suit attracts all the black soot and lint in the neighborhood.

Several of the synthetic plastics and fibers have been used to make so-called allergy-free pillow cases and garments because of their clean lint-free nature. But, if these articles become easily charged with static

electricity under certain conditions, the attraction of almost invisible particles of dirt and spores and bacteria completely defeats the original purpose behind their use.

Finally, there is the special case where fabrics of certain of the new synthetics are made into garments for use in refinery and chemical plants. Their high resistance to chemical attack has offered a wonderful new protection to the worker. Their use, however, has also offered a potential explosion hazard because of their ability to build up static charges to the point where explosions of solvents may take place.

Now, all of these problems offer a real challenge. For the new synthetics have so many advantages that their use will increase in spite of static.

Chemical Antistatic Agents

In theory, the use of a chemical antistatic agent on the textile is the ideal method for controlling static electricity in the textile. Electrical devices can only be used at certain points past which the textile travels, and humidity can only be used to control static under certain conditions, and satisfactorily only with the older fibers. A chemical antistatic agent, however, can be put on the fiber and it will travel along with the textile to do its work at every point. Also, from the consumer standpoint the use of chemical antistatic agents is the only possible answer to static control in textiles.

This does not mean that there are no problems in connection with chemical antistatic agents. There is the problem of where to apply the antistatic agent. Should it be easily washed off, or should it be fast? What about the effect on the hand, on strength, and on the appearance of the fibers? We often must take into consideration its compatibilities with many materials. We must think about whether it will affect the light-fastness of the colors, or whether it will develop an odor. In fact, use of chemical antistatic agents poses many problems. But inherently, only by the use of chemical antistatic agents can we look for a real solution to the problem of static control in textiles.

How a Chemical Antistatic Agent Works

Actually all of the mechanisms whereby a charge can be neutralized before it builds up, and the ways whereby charges can leave the fibers, may be taken advantage of in the use of chemical antistatic agents. This does not mean that all these agents make use of all of these means but theoretically they could.

The mechanism whereby most chemical antistatic agents do their work is in the field of conductance. Now, even if the antistatic agent also makes use of other processes it always has some effect in improving the surface conductivity of the fiber, and thereby helping the charges to go more readily to ground or to the atmosphere. Any surface active agent which forms ions in solution, when placed on the surface of a fiber, even in minute amounts, must improve the surface conductivity of the fiber. On this basis, a film of soap, sulfonated oil, or synthetic detergent will improve the surface conductance of fibers, and will theoretically assist in the removal of static. It must be borne in mind, however, that while most chemical substances applied to a fiber will increase the surface conductivity of the fiber, some chemicals are many times more effective than others in this respect. Now this is due to some fundamental relationship not understood and only partially related to the conductivity powers of the chemicals themselves in solution. There are indications, however, that the improvement in surface conductivity caused by chemical antistatic agents is related to the type of film the agent forms on the fiber, and to the way in which the molecules are oriented on the fiber.

Another way whereby a chemical antistatic agent can do its work is in the matter of hygroscopicity. This is particularly important with the new low regain synthetic fibers. We have known that the presence of moisture on the surface of a fiber would assist in the lowering of the surface resistance of the fiber and hence improve the rate of charge removal. Antistatic agents which are hygroscopic thus can do part of their work by furnishing molecules of water right on the surface of the fiber. This water also serves to activate further the chemical antistatic agents by partial solution of the active groups of the agent in the water.

Thirdly, a chemical antistatic agent may do its work by developing a charge opposite to that formed within the fiber itself when the treated textile is rubbed or comes in contact with another substance. This mechanism also seems to be related not only to the chemical nature of the antistatic agent but also to the orientation of molecules of the agent in the film put on the textile fiber, and on the nature of this film.

A chemical antistatic agent can thus do its work by any one or all three of the above-mentioned ways. It appears, however, that in order to be really effective, an antistatic agent should make use, at least to some extent, of all three.

In passing, we must not neglect to mention the possibility of the incorporation of radioactive elements within the molecule of the antistatic agent itself. It is possible to visualize a chemical antistatic agent something like a one-man band. In such a Utopia, we can see charges being conducted away to the air and to the ground, opposite charges being formed and neutralizing other charges, and at the same time the fiber being constantly bombarded with charged ions.

In conclusion, we may say that the static problem in textiles is being attacked from many angles. The manufacturers of the synthetic fibers are studying the fundamental properties of these fibers as related to the development of static electricity. Some of the national technical societies have committees at work on the problem. The manufacturers of finished textiles are carrying on extensive research projects. With the work of the past as a foundation, new ideas and new principles are being developed. This increased activity must lead to a cure for the "headache" of static electricity.

References

19. Alessandro Volta, "On the Electricity Excited by the Mere Contact of Conducting Substances of Different Kinds," *Philosophical Transactions*, 1800, pages 403-431.

20. Lopez and Hewson, *American Dyestuff Reporter*, 41:105 (1952).

The Modern Writer and Natural Science

More Important Than Its Details Is Understanding of Broad Principles of Science

By H. B. PHILLIPS

WHEN asked to take part in a recent conference of the Modern Language Association of America, I informed the chairman that I would try to state briefly what I thought the modern writer should know about natural science. I am not a writer, modern or otherwise, but have been interested all my life in science and have definite ideas concerning the part writers might play in enabling science to reshape the world. My remarks at the conference are presented in this brief article.

The whole universe, including living as well as nonliving things, forms one complex system. Changes in this system do not occur arbitrarily but follow definite rules, or laws. It is the business of the scientist to determine those rules and apply them. He does this partly because of his desire to know, and partly because this knowledge may enable him to influence the course of events.

To report such events is the business of the writer who uses language to picture the world as he sees it, both in reality and in imagination. He does this partly because he enjoys the process and partly because these word pictures may influence other people to proceed in the direction he wishes them to go.

If the picture he paints is to be a valid one, it must be in accord with the real world.This does not mean that he must know the details of science but only its most general principles. He may be unable to play any musical instrument; but, if he thoroughly appreciates musical harmony, his writing will have a quality which otherwise would be lacking. He may be unable to paint anything; but, if he appreciates the work of the great masters, his writing will have a finish which otherwise it would not have. He may be unable to pass an examination in any one of the sciences; but, if he has a general understanding of the nature of the sciences and what can be accomplished by scientific methods, his writing is more likely to help, and not to hinder, the general course of progress.

To show the effect of neglecting science, a few examples are presented. The November, 1952, issue of the *Atlantic Monthly* contains an article by C. S. Forester entitled "Could Napoleon Have Won?" Forester shows that the arms used by Napoleon's troops were completely obsolete. The English were using the rifle, the French had only the smoothbore. The English had shrapnel, the French only round shot for their cannon. It was not necessary for Napoleon himself to remedy these defects. The French scientists and engineers were the ablest in the world. They would undoubtedly have gladly done the job for him. Napoleon's error consisted merely in not recognizing the importance of technology.

In the Senate debate last year, a proposal was made to reduce the appropriation for research in aeronautics. Immediately following this was a proposal to increase the appropriation for housing at the air fields. No one suggested that present housing was inadequate, but merely that better housing would increase the comfort of the men. A number of senators, including several who proudly call themselves liberal, voted to reduce the appropriation for research and increase that for housing. These senators did not understand the role research plays in aeronautics.

To this many would reply that these details should be left to experts. Why bother us with such matters?

The answer is that on every question of this kind there are experts on both sides. Someone must decide which experts shall have their way. In an autocracy that decision can be made by the dictator. In a democracy it must be made by the ordinary people. How then are people to have a basis for decision?

The average person completes his school or college education in his early twenties. Thereafter, for perhaps 50 years, he keeps up, at most, with some narrow specialty. Much that he learned in school has become obsolete 10 years after graduation. As he grows older, whatever competence he has to handle contemporary matters becomes more and more dependent on what he has learned after leaving school. The principal source of such education is general reading. In fact the greater part of it comes from reading fiction. What little history I know was almost all learned from novels, most of which were not even historical novels. What little understanding I have of social problems was acquired in the same way. What importance the ordinary citizen ascribes to science is determined largely by the atttude of writers who never wrote a word about science.

It is not what they directly say that is important but what is read between the lines. From a single chapter in a book a skillful detective could, in many cases, determine the whole philosophy of the writer. A casual reader consciously follows only the story. Subconsciously he acquires the same philosophy. What is wanted in general literature is, then, not the content, but something of the spirit, of modern science.

To the scientist, creation is not an operation completed billions of years ago but a process now going on and which will always continue to go on. This eternal process of creation is what life is and what life is for. In harmony with this view, one would like literature which portrays a world where philosophy is less concerned with what we are, more with what we might be; where politics is less concerned with distribution, more with production; where wealth is measured less by possesson of old things, more by capacity to create new things; where the characters of fiction are less a group of neurotics and parasites, more a group of people who do something really worth while.

Mechanical Engineering

Undergraduate Professional Training Benefits from a Mature Program of Graduate Study and Research Combined with Intimate Contacts in Industry

By C. RICHARD SODERBERG

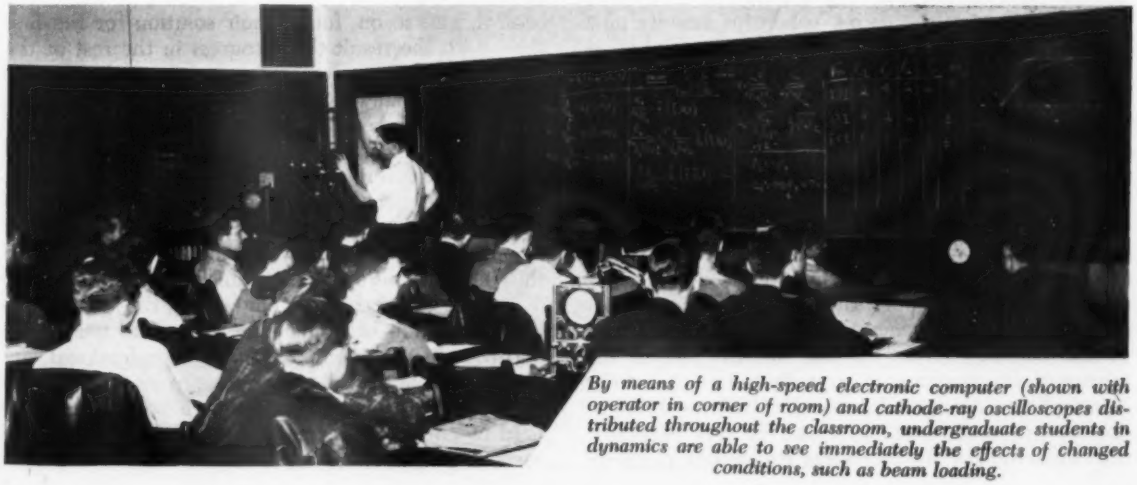
THE Institute has always been characterized by the high degree of autonomy which it confers upon its departments, many of which have enjoyed an unbroken existence since M.I.T. was founded, nearly a century ago. The Department of Mechanical Engineering is one of the oldest of these departments, and, within its domain, it displays a most varied spectrum of activity in education, research, development, and service to industry.

Such an extensive and variegated range of undertakings represents a far cry from the severely limited teaching activities which were carried on when the Institute commenced its operations in the 1860's. The changes and transitions which have taken place during the last 80 years have evolved gradually with the requirements for expansion of operations, and perhaps can best be appreciated when reviewed against a background of historical perspective.

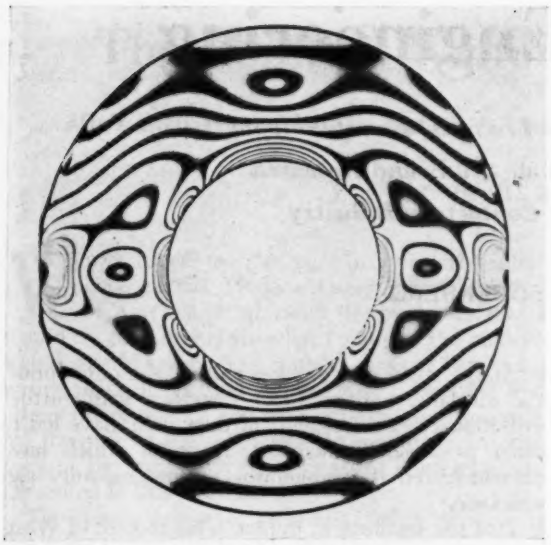
Mechanical ingenuity is certainly one of the outstanding traits of Western man, and consequently, mechanical engineering may be regarded as a major branch of the technological developments of Western civilization. Man began making substantial improvements in his material status when he started to substitute power developed by mechanical means for that previously obtained from human and animal sources. The search for mechanical power led initially to the harnessing of wind and water and then to the development of the steam engine, which in turn stimulated the development of machine tools and production methods of manufacturing. The subsequent major inventions of the cotton gin, the power loom, the steamship, the locomotive, the automobile, the airplane, and so forth, together with further evolutionary developments of their own, have led to other professional offshoots, many of which have overshadowed the progenitor in contemporary significance.

That the Institute is, in fact, a microcosm of Western technology is merely a manifestation of the fact that M.I.T. has played a significant role in technological progress. In view of the cataclysmic changes which have taken place with the evolution of modern technology, it is reassuring and comforting to find entities which have kept pace with technical progress and yet maintained their own individuality.

The Department of Mechanical Engineering is one such entity. When the Institute's doors were first opened for classes, the original faculty of 11 members included William Watson, Ph.D., who held the title of Professor of Descriptive Geometry and Mechanical Engineering. From this title one can appreciate that, according to modern standards, the activities in Mechanical Engineering must have run on a very small scale indeed. When Professor Watson resigned in 1873, he was succeeded by an M.I.T. Alumnus, Channing Whitaker, of the Class of 1869, who was appointed assistant professor of mechanical engineering. In a very short space of time the Department grew to such a size that its teaching could no longer be handled effectively by a single professor. In fact, by the turn of the century, Mechanical Engineering had the largest enrollment of any course at the Institute. Half a century later,



By means of a high-speed electronic computer (shown with operator in corner of room) and cathode-ray oscilloscopes distributed throughout the classroom, undergraduate students in dynamics are able to see immediately the effects of changed conditions, such as beam loading.



A quarter of a century ago, photoelastic stress studies were undertaken only in advanced research laboratories, but today every undergraduate in Mechanical Engineering has opportunity to learn how to interpret stress patterns shown here.

the records show that the Institute had awarded more than 5,000 degrees to students in the Department of Mechanical Engineering. Although most of these have been bachelor's degrees, the Department is also proud of having trained almost 800 men who have received the master's degree and some 70 upon whom the doctorate has been conferred.

Role of the Mechanical Engineer Today

Since mechanical engineering activities are now diffused throughout practically all industrial operations, it is difficult to assign specific boundaries to the profession. The only fields of mechanical engineering endeavor which, throughout the years, have remained within the traditions of the profession are those dealing with power and manufacturing. These fields continue to provide inspiration for creative activity, and experience affords ample proof that professional opportunities within these areas are just as rich today as they were a generation ago.

That the mechanical engineering profession is facing a continually growing sphere of activity and opportunity is well demonstrated by recent achievements, some of which have received much greater publicity than others. Perhaps the most spectacular of these achievements is represented by the engineering which has culminated in the development of the gas turbine as a new form of heat engine. In less than a decade this development has brought about a complete revolution in aircraft propulsion. However, developments of great importance have also occurred in numerous less publicized accomplishments. For example, the steam power facilities for electric power generation have nearly doubled in this country during the last decade, and in the course of this increase in capacity very noteworthy accomplishments have been made, both in terms of the size of individual units and in fuel economy. The utilization of atomic energy for civilian purposes will soon confront this industry with a new challenge. In the transportation industry some very striking developments have taken place since the end of World War II. Our railroads have succeeded in refurbishing their rolling stock and now operate largely with Diesel-electric motive power instead of steam. Commercial air transportation has reached the stage of jet propulsion. Natural gas from the fields of the Southwest has been made available in the North and East as a result of pipe-line developments of remarkable scope. At the same time, a very noteworthy increase in the national productive capacity has taken place. This has been accomplished not only by the development of new and more efficient machines and methods, but also by the engineer's ingenuity toward increasing the output of existing equipment. The entire field of machine tools is currently undergoing a quiet revolution as a result of the application of basic scientific research to problems of metal cutting, metal forming, and automatic control.

Developments such as those mentioned above fall directly within the scope of the mechanical engineer's activities and represent more or less direct applications of his training. In addition, however, the role of the mechanical engineer is equally significant in many of the other engineering specialities. Regardless of the major field involved, the majority of the engineering problems to be solved usually present a great many aspects which fall within the scope of mechanical engineering.

In the course of time, each field of engineering seems to go through a certain pattern of development. Following an initial phase of basic invention and application of new scientific principles, there occurs a period of consolidation in which problems of practical application are encountered in their full dimensions. Although plateaus of consolidation are sometimes regarded as being devoid of exciting developments, it is actually during this stage that most of the significant advances in the mechanical engineering aspects are made.

The design of electrical machinery went through such a consolidation about 30 years ago, when a whole series of significant problems in mechanical engineering had to be faced. Basic engineering problems in strength of materials, vibration, automatic control, and so on, found their solution for the first time, with the result that progress in the rest of the industrial complex was much accelerated.

There are many signs that other branches of engineering are currently undergoing similar epochs of consolidation. The chemical engineering industry has become increasingly aware that the special competence of the mechanical engineer is indispensable to success. Organizations in the aircraft, petroleum, and chemical manufacturing fields are especially alert to the contributions of the mechanical engineer.

The young mechanical engineer is thus in the fortunate position of being able to look to nearly the entire industrial complex for his professional opportunities. Success in his career may require that he achieve special competence in some particular field of employment, and eventually, as a result of assuming various specialized duties, he may no

longer be recognizable as an mechanical engineer. It is only fair to concede that the reverse process can also take place.

The facility with which a man trained in one branch of engineering is able to embark upon a successful career in another field is one of the sources of strength in American engineering education, in which the process of professional development is assumed to begin in earnest with the award of the bachelor's degree. Training in mechanical engineering, which provides a general background in technology, enables the young graduate to be poised for real opportunities whenever and wherever they arise. At the same time, the objective of a universal type of training, to suit all roles in which mechanical engineers may find themselves, creates difficult problems in planning an educational curriculum and in supporting professional activities of the Department of Mechanical Engineering.

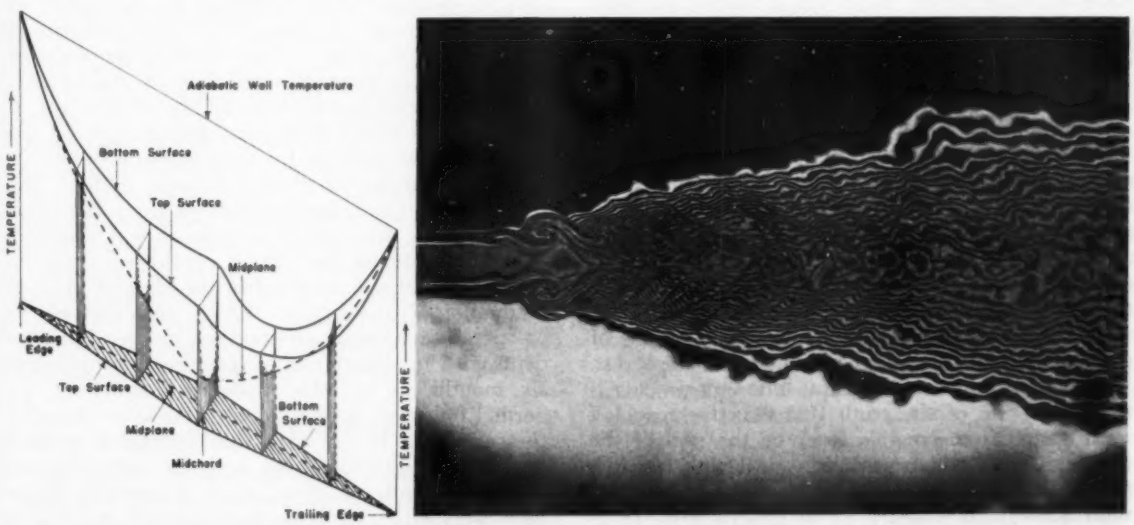
Graduate Education and Industrial Relations

For many years the mechanical engineering program at M.I.T. consisted primarily of the undergraduate curriculum. Along with many similar institutions, M.I.T. followed the premise that effective professional training in engineering could be made part of a four-year undergraduate program. This scheme has been successful in furnishing appropriate training for the majority of men entering industry, but it does not provide the lifeblood of creative work which is so desirable for teachers, nor does it meet the recent demands of industry for engineers with advanced professional training.

Graduate work leading to the doctorate in Mechanical Engineering commenced in the 1920's and had already become significant by 1940. However, the real expansion in graduate training occurred as part of the upswing which took place in professional education at the end of World War II. The beginning of a truly professional program in mechanical engineering, in which the undergraduate program is fed by a synthesis of research combined with advanced and mature study, is then a product of the last decade. A well-developed program of graduate study and research can attract the outstanding leader in science or technology, and in turn his presence on the Faculty attracts the gifted student who becomes creative in research or teaching.

The growth of graduate professional training in the Department of Mechanical Engineering has been accompanied by an increasingly intimate relationship with industry and the practical realization that industrial experience and connections form an essential background for all who teach mechanical engineering subjects. Because of the difficulties involved in attracting men with promising careers in industry into academic life and of enabling teachers to acquire worth-while industrial experience in the past, there appear to have been periods during which teaching lacked vitality as a result of loss of industrial contact. However, a decided step forward was made when outstanding industrial practice along the lines of development and research was recognized as equivalent to academic merit in similar undertakings. This philosophy and continued opportunity for industrial contacts have now made it possible to attract outstanding men from industry to the teaching profession. At present, several of the leaders in the Department have had the benefit of mature industrial experience, and much has been gained in this respect.

The continued growth of the undergraduate program provides ample proof of the invigorating influence of these developments. There is every reason to believe that the demand for undergraduate education in mechanical engineering will increase. For the majority of the undergraduates, the four-



Students working on theses helped to determine (left) *the temperature distribution, shown here, along a wedge-shaped aircraft wing traveling at very high supersonic velocities. Interferometer photographs* (right) *which record changes in the refractive index of a substance, provide students with another effective method of analysis. The nozzle at the left discharges carbon dioxide into air. As air and carbon dioxide mix, the variations in density of the combination produce changes in the refractive index of the mixture which appear as alternate light and dark bands. Such interferometer patterns have been used by students studying nozzle design, or to determine how gases mix in combustion chambers.*

year curriculum is still a good compromise between the pressure for increased professional background and the need to begin one's career in the competitive world. The minority who go on to graduate work will already have absorbed, from their undergraduate program, a basic philosophy and mature point of view which is invaluable in advanced studies.

Professional Scope of the Department

With the development of graduate education, it has become easier for the Department of Mechanical Engineering to reorganize certain of its groups and to promote professional orientation in specific directions. Some groups, such as those in applied mechanics, fluid mechanics, materials (including plastics and textiles), thermodynamics, heat transfer, and stress measurements, are oriented toward fields of applied science. Others, such as those engaged in machine design, automatic control, metal cutting, metal forming, and machine tools, are oriented toward processes. Finally, there is a group oriented toward specific devices, such as power plants, heating and air-conditioning equipment, internal combustion engines, and gas turbines.

While acceptable for the present as a device of operation, this structure is not intended to present a complete synthesis of mechanical engineering. Naturally, no clear definition exists as to the exact scope of this field of engineering, or even the supporting disciplines of applied science. Actually, the field contains a very large number of specialities, of which only a few can find adequate representation on the staff or in the curriculum.

The assumption that a field as extensive as mechanical engineering could be delineated by definite boundaries has been harmful, since frequently this has led to the retention in the curriculum of outmoded problems and concepts or to superficial treatment of subjects of great scope, when a more penetrating treatment of fewer topics might have provided a better training.

Educational Philosophy

Far more important than matters of external form are the ideas and ideals which underlie educational activities. These can find their expression only through individual teachers and, in the last analysis, no program can do more than provide the means of expression for the ideas of men on the staff. There is a gradual evolution going on in professional education which promises much for the future. Some of the major trends of this change may be of interest.

First and foremost in this evolutionary process is a reaffirmation of the truth that effective teaching must spring from creative work on the part of the teacher. This creative work may deal with research in the academic institution, or it may be connected with activity in industry or in government. Technological education, in particular, cannot prosper in sterile academic forms. It must feed on life itself, and anything which is significant in the technological activity of our society is worthy of serious study and the most imaginative application of scientific rigor.

These ideas were part of the basic philosophy of the Institute from its beginning, but in the course of time they came to be forgotten. In the process of revitalization of the Department of Mechanical Engineering which started two decades ago, attention was first given to the synthesis of applied sciences. The program was strengthened both with respect to scientific rigor and the relevance of the subjects to the problems of the industrial world. The process started with thermodynamics and fluid mechanics and continued through applied mechanics, particularly vibrations, control phenomena and strength of materials. The internal combustion engine and the gas turbine served as inspiring ultimate objects of application. The most recent field to be given strengthened scientific rigor is that of materials, especially certain aspects of solid state physics which have applications not only in metals but also in plastics and textiles.

Equally important as this infusion of scientific methods is the increasingly close contact with industrial operations. The bonds which unite industrial enterprises and professional institutions of learning are much stronger than they formerly were, but they need continual strengthening and reinforcement, and not only for the financial issues involved.

The response from industry to a program of co-operation between industrial and educational groups is extremely encouraging, even though many major industrial enterprises remain to be convinced that active co-operation with universities is worth while. Industrial leaders often observe, with a touch of impatience, that the engineering schools should occupy themselves with teaching the fundamentals of science, leaving to industry itself the training in technological practice. This argument has a certain force of logic but it does not take into consideration one of the most important aspects of the educational process. The boy who studies engineering usually does so because he is interested in machinery as well as in science. A great deal of the enthusiasm he feels for his studies is derived from the sense of relevance to the external world that his studies give.

This argument has no less validity for the part of the program which is labeled Humanities or the Social Sciences. Indeed, the very names should be a constant reminder of their relevance to life. The Institute has taken important steps in recent years to strengthen this part of its educational program.

The Department has always considered some industrial experience essential to the student prior to graduation. To facilitate this it has revived its co-operative training program which provides students with an opportunity of spending approximately six months in industry without lengthening the normal four-year undergraduate course or changing the curriculum in any way. This program is working out very satisfactorily from both the industrial and academic points of view, since it provides future employers with a really good opportunity to estimate a man's ability and it enables a student to make firsthand observations of certain of the technical aspects of industry, as well as those daily human relationships which are so important in everyday life.

(*Continued on page 442*)

Problem of Ionizing Radiation

The Difference between Beneficial and Harmful Effects of Radiation Is Mainly One of Control

By HAROLD BAVLEY

THE birth of the Atomic Age occurred not with the explosion of the first atomic bomb in 1945, but just 50 years prior to that memorable event with the discovery of x-rays by an obscure physics professor named Wilhelm Konrad Roentgen, while he was engaged in research at the University of Würzburg in Bavaria. Professor Roentgen discovered that, by use of a relatively high vacuum tube invented by an Englishman, Sir William Crookes, the rays emanating from such a tube when a high-voltage current is sent through it, would penetrate objects which were opaque to ordinary light and would also affect a photographic plate. After short but intense study of this new phenomenon, he submitted to the local scientific society his findings on this new type of ray. The news of his discovery was widely publicized by newspapers and periodicals throughout the world, and everyone at that time became x-ray conscious. Dramatization of this new mysterious power, and the accompanying stories, cartoons, and poems, caused an hysteria among the populace because it came to be believed that these strange rays could "see" through anything. An irate New Jersey assemblyman introduced a bill in the state legislature prohibiting the use of these penetrating rays in opera glasses at theaters, and in London a firm "made prey of the ignorant women by advertising the sale of x-ray proof clothing."

A few popular newspapers, both here and abroad, vehemently declared that the Roentgen rays should be banned, the discoverer executed, and all x-ray equipment dumped into the sea. Some of Roentgen's contemporaries accused him of being a mercenary scientist, when the truth really was that Roentgen sought no reward nor received any monetary gain except the Nobel prize for physics in 1901. Whether Roentgen wished it or not, he became famous almost overnight. He received a decoration and a title from Wilhelm II, Emperor of Germany; and boulevards and streets were named after him.

X-rays — Their Nature

Roentgen rays or x-rays are considered to be electromagnetic radiations or vibrations (similar to ordinary light [4,000–7,000 angstroms] but of much shorter wave lengths – 10–150 angstroms) set in motion when electrons, moving at a high velocity, impinge on certain substances, especially the heavy metals. These rays are generated by passing a current, at high voltage, through a highly exhausted vacuum tube. The radiations emanate in "bundles" or "packets" from the x-ray tube, and are not homogeneous but are made up of different wave lengths. The shorter wave x-rays are more penetrating and are known as "hard" rays; the longer wave, less energetic rays are known as "soft" rays. The higher the voltage, the shorter the wave lengths and the more penetrating the rays. The hard x-rays, therefore, are more dangerous to the deeper tissues and organs within the body; the soft rays are more easily absorbed by the outer layers of tissue, and present, if uncontrolled, a serious hazard to the skin. Where x-ray is used for other purposes than skin therapy, filters, such as aluminum, are usually provided to absorb most of the unwanted softer radiation. There were many difficulties to surmount before an x-ray tube was developed in 1913 by William David Coolidge, '96, making it possible for the operator to control the output of x-rays. Prior to this invention, it was necessary for the radiologist to have on hand several different sizes of tubes and also to have the ability of estimating the output, an obvious danger. Even the earliest Coolidge tubes were capable of continuous, stable operation at voltages up to 200,000 volts. The Coolidge tube using a high vacuum and a tungsten target, oil insulated and water cooled, at present enjoys popular use. Dr. Coolidge developed the sectional x-ray tube operating on the cascade principle. After further research, it was found that by using Freon gas instead of oil as insulation, it was possible to develop the 1,000,000- and 2,000,000-volt units which are today used by hospitals and industry.

One source of hazard results from the uncontrolled scattering of x-rays by reflection, refraction, and diffraction. Scattering becomes increasingly important at short wave lengths because of its increased ability of penetration. Suitable precautions such as location, shielding, and so on, are extremely necessary to prevent any unintentional exposure to operators and related personnel.

The ability of x-rays to cause ionization of matter, indirectly, aids in the quantitative measurement of the rays. An arbitrary unit of measurement (named in honor of Röntgen) has been devised, based on the resulting ionization caused by the rays. The roentgen is defined as that amount of x-rays which will produce one electrostatic unit of ions in one cubic centimeter of air under standard conditions of temperature and pressure. Because ionization is produced by a "radioactive source," the roentgen is used also as a unit of measurement of the ionization produced by the radio-

active substances. Suitable instruments have been developed to measure the amount of ionization produced by x-rays and are a means of evaluating the potential hazard.

X-rays — Their Injury Experience

Soon after the discovery of x-rays, the claims which Roentgen had made for these new rays were substantiated, and workers in medicine and science soon realized the importance of this discovery, particularly in diagnosis and treatment. However, there was no appreciation of the hazard presented by these rays, for little was known except that the rays could be created and used as a part of a valuable technique. Within a period of one half to two years from the date of discovery, a series of injuries were reported among the personnel using x-rays. In 1907, Dean reported 20 to 30 cases of occupational dermatitis in Great Britain. By 1911, Krause reported that 26 cases of carcinoma were recognized among the medical staff, 24 cases among the technical staff manipulating the apparatus, and 4 among patients treated. During the same era, Hesse cited 94 cases of carcinoma.* Kaye states in his book *Roentgenology*,† "A succession of deaths from aplastic anemia brought matters to a head in England in 1921. Public opinion was stirred and the assurance companies began to regard the roentgen-ray worker with an unfavorable eye."

The number of x-ray injuries resulted in the formation of committees among the various scientific groups for the promulgation of rules and regulations for the proper use of equipment producing x-rays, and for the protection of the personnel who might use or be exposed to this potentially dangerous source of ionizing radiation. The codes developed for the safe use of x-rays have served as a foundation for codes developed for the prevention of injury from other sources of ionizing radiation, such as natural and artificial radioactive isotopes. Unfortunately, there are those who, due to unfamiliarity or lack of knowledge of the hazards of x-rays, are still being injured even at this time. In 1941, in a West Coast shipyard, unauthorized persons, uninstructed in the use of industrial x-ray equipment, entertained themselves by observing their hands and feet on a fluorescent screen. The ensuing injuries to 59 employees were of such severity as to result in amputations in several of the injured personnel. This tragic example emphasized the need of rules and regulations governing the handling of x-ray equipment.

X-rays cause both local and systemic injury depending upon the quality, quantity, and dosage. Locally the skin may be affected in many ways. Small daily doses may cause the skin to become dry and inelastic, with the nails becoming striated and brittle; in addition, painful wart-like growths may appear on the skin. When exposure is high, a severe burn may result. If the skin is damaged to any great extent, ulcers or cancer may develop. Temporary or permanent sterility may result from a high degree of exposure localized in the area of the reproductive organs. Injury and defective changes due to excessive radiation may occur in the fetus when the uterus of a pregnant woman is subjected to excessive x-radiation. Systemically, excessive exposure may cause damage to the blood-forming organs, and dyscrasias, such as leukemia, leukopenia, and aplastic anemia may result. Excessive exposure can cause cancer, destruction of the bones, or both. In several cases, which have been studied, the injury has progressed to a fatal termination.

The ionization of tissue results in the damage just mentioned. X-rays and radioactive substances will produce similar injuries, the severity being dependent upon the amount of ionization produced in the body.

First Commercial Use of X-rays

X-rays were first used commercially (for nonmedical purposes) in 1922, at the Watertown Arsenal as an aid in furthering the development of improved foundry techniques. Detection of hidden defects, such as cracks and blowholes in castings, and defects in alloys from faulty mixtures by means of x-rays, assured the use of satisfactory castings where needed. Besides its use in metallurgical inspection, x-rays provide industry with the means to learn about the "inside" of any article without destroying it in any way. X-rays may be used in two ways. Many articles may be examined by fluoroscopy, in which a shadow image is formed on a fluorescent screen. Fluoroscopy is of value in determining whether or not component parts of an article are in proper position and may also be used to sort vegetables, fruits, and so on, revealing spoilage or adulteration of the product. X-rays are employed also in obtaining permanent records. Instead of the image appearing on a fluorescent screen, it is recorded permanently on photographic film. Radiography is of value not only for determining whether a product has been manufactured satisfactorily, but may be also used in analytical determination of mineral substances by photographing the diffraction pattern.

Radioactivity — Discovery and Development

In his search for substances which would affect a photographic plate similar to x-rays, Henri Becquerel discovered in 1896 the phenomenon of radioactivity during the investigation of uranium. The Curies, following Becquerel's research, discovered radium and produced it in its metallic form in 1902. However, radium as we know it today is produced as a salt of radium; as a chloride, a sulfate, a bromide or a carbonate. The manufacturing method used by Madame Curie and André Debierne is still the method of choice today. This method consists of three stages involving the grinding of ore, treatment with acids, and the elimination of the acids by washing and fractional crystallization. Other radioactive elements discovered by the Rutherfords and the Curies, by separating and identifying the radioactive compounds, led to the de-

(*Continued on page 446*)

* *Occupation and Health* (Geneva: International Labour Office, 1934), II:777–786.

† George W. C. Kaye, *Roentgenology: Its Early History, Some Basic Physical Principles and the Protective Measures* (*New York:* Paul B. Hoeber, Inc., 1928).

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

From the Ballot Box

BALLOTS for election of officers to guide the affairs of the Alumni Association for the fiscal year which begins on July 1, 1953, were counted on April 25 and indicated that the men named below will serve as officers of the Alumni Association, alumni term members of the M.I.T. Corporation, members of the National Nominating Committee, and class representatives on the Alumni Council.

Horatio L. Bond, '23, will ably fill the office of president of the Association for one year. The vice-presidency will be held by Richard S. Morse, '33, and the two new members of the Executive Committee are Avery H. Stanton, '25, and Frederick B. Grant, '39. Messrs. Morse, Stanton, and Grant will serve for terms of two years.

Elected to serve as alumni term members of the M.I.T. Corporation for a period of five years are: Clarence D. Howe, '07, Edwin D. Ryer, '20, and James H. Doolittle, '24. To fill the unexpired term of the late C. Adrian Sawyer, Jr., '02, on the M.I.T. Corporation, Robert C. Sprague, '23, was named.

Members of the National Nominating Committee for their respective districts have been chosen for a term of three years, as follows: Laurence P. Geer, '15, for District 8; Robert J. Joyce, '28, for District 9; and Richard L. Cheney, '27, for District 10.

To serve a five-year period, Class Representatives on the Alumni Council were voted on by members of the classes whose numerals end in four or nine, with the following results: George Owen, '94, Miles S. Sherrill, '99, Eugene H. Russell, Jr., '04, Arthur L. Shaw, '09, H. B. Richmond, '14, George W. McCreery, '19, G. Raymond Lehrer, '24, Eric A. Bianchi, '29, Henry B. Backenstoss, '34, Frederick B. Grant, '39, Robert D. Peck, 2–44, Albert B. Van Rennes, 10–44, and Archie H. Harris, 3d, '49.

A count of the ballots shows 3,148 valid votes cast for officers of the Alumni Association and for members of the National Nominating Committee; 2,598 for alumni term members of the M.I.T. Corporation.

Class Reunions

Listed below is the latest available information on class get-togethers and reunions which are to be held in conjunction with Alumni Day on Monday, June 15, and on other dates:

1891 June 13. Dinner at 1:00 P.M. at The Country Club, Brookline, Mass.

1893 Dinner at M.I.T. Faculty Club. Leonard B. Buchanan, reunion chairman, Stone and Webster, Inc., 49 Federal Street, Boston.

1898 June 15–17. Reunion headquarters after Alumni Day, June 15, at Hotel Vendome, Boston. June 16, guests of Roger Babson at Wellesley; June 17, The Country Club, Brookline, Mass. Lester D. Gardner, reunion chairman, 875 West End Avenue, New York 25, N.Y.

1900 June 16–18. The Pines, Cotuit, Mass. Elbert G. Allen, Secretary, 11 Richfield Road, West Newton, Mass.

1903 June 12–15. June 12, participation in commencement exercises; June 13 and 14, 50th reunion celebration at Coonamessett Ranch Inn, North Falmouth, Mass.; June 15, participation in Alumni Day events. Carlton F. Green, reunion chairman, Stone and Webster, Inc. , 49 Federal Street, Boston.

1905 June 19–21. Wianno Club, Osterville, Mass.

1908 June 12–14. Snow Inn, Harwich Port, Mass. H. Leston Carter, reunion chairman, 14 Roslyn Road, Waban 68, Mass.

1911 June 19–21. Informal get-together at Snow Inn, Harwich Port, Mass.

1913 June 12–14. Oyster Harbors Club, Osterville, Mass. William R. Mattson, reunion chairman, 28 Brookdale Road, Newtonville 60, Mass.

1916 June 5–7. Coonamessett Ranch Inn, North Falmouth, Mass.

1918 June 12–14. Weekapaug Inn, Weekapaug, R.I. Reunion chairmen: Max Seltzer, 87 Ivy Street, Brookline, Mass.; Saxton W. Fletcher, 880 North Street, White Plains, N.Y.

1921 June 15. Class cocktail party at Hotel Statler, Boston, preceding Alumni Banquet.

1922 June 15. Cocktail party at Hotel Statler, Boston, preceding Alumni Banquet.

1923 June 11–14. Sheldon House, Pine Orchard, Conn. Channing P. Clapp, reunion chairman, 210 Main Street, Matawan, N.J.

1928 June 12–15. 25th reunion at Baker House, M.I.T., Cambridge, June 12–14. Participation in Alumni Day events, June 15. William H. Carlisle, Jr., reunion chairman, Room 5-121, M.I.T., Cambridge.

1933 June 12–14. Wentworth by the Sea, Portsmouth, N.H. Charles C. Bell, Universal Winding Company, Elmwood Avenue, Cranston, R.I.

1938 June 12–14. Curtis Hotel, Lenox, Mass. A. Louis Bruneau, Jr., reunion chairman, 412 Ponfield Place, Ridgewood, N.J.

1943 June 12–14. Mayflower Hotel, Plymouth, Mass. James F. Hoey, Jr., reunion chairman, 1826 Center Street, West Roxbury 32, Mass.

1948 June 13–14. Mayflower Hotel, Plymouth, Mass. Richard H. Harris, reunion chairman, 26 South Street, Grafton, Mass.

For further information, please consult your class secretary or reunion chairman to make arrangements for attending a class get-together and the events of Alumni Day on June 15.

Alumni Day, 1953

CLIMAXING reunion activities for several classes, as well as celebrating a yearly occasion for others, will be the events of Alumni Day on Monday, June 15. Alumni who return to Cambridge for this annual event will participate in a day planned for the enjoyment of good fellowship evoked by a renewal of friendships and of familiar sites.

Registration will be in the morning in the lobby of Building 7 (Rogers Building), and at 10:30 A.M., the following Departments will hold open house: Aeronautical Engineering, Biology, Business and Engineering Administration, Chemical Engineering, Civil Engineering, Electrical Engineering, Food Technology, Mechanical Engineering, and Naval Architecture and Marine Engineering.

A buffet style luncheon is scheduled at 12:30 P.M. in the Great Court, when James R. Killian, Jr., '26, President of the Institute, will address the guests. The World War II Memorial, in the lobby of Building 10, will be dedicated at 3:00 P.M., and following the dedication, President and Mrs. Killian will welcome Alumni at an Open House at their home at 4:00 P.M.

Topping the day's events for Alumni, at 7:00 P.M. will be the annual Stein-on-the-Table Banquet at the Hotel Statler. Erwin D. Canham, editor of the *Christian Science Monitor,* will be the principal speaker at the banquet, and presentation of gifts to M.I.T. will be made from the 25- and 50-year classes. Alumni who attend the banquet will receive a new stein designed by Henry B. Kane, '24, Director of the Alumni Fund, to add to their collection. At the Statler, there will also be a special banquet for the ladies at which the speaker will be Mrs. Elspeth D. Rostow, Assistant Professor of History in the M.I.T. Department of Economics and Social Science.

Chairman and cochairman, respectively, for Alumni Day, 1953, are George W. McCreery, '19, and Theodore T. Miller, '22. Those serving on subcommittees follow: *Banquet:* Donald W. Kitchin, '19, chairman, Arthur H. Blake, '19, James Donovan, '28, Eric A. Bianchi, '29, Clarence R. Westaway, '33, Albert O. Wilson, Jr., '38, Richard J. Zeamer, '43, Harl P. Aldrich, Jr., '47, Richard H. Harris, '48; *Departmental Reunions:* Carl F. Floe, '35, chairman, Philip A. Stoddard, '40, Kenneth R. Wadleigh, 43; *Luncheon:* E. P. Brooks, '17, chairman, Alan W. Burke, '20, Chenery Salmon, '26, Randolph Antonsen, '35, Frederick B. Grant, '39, Oswald Stewart, 2d, '39, Theodore P. Heuchling, 2-46, Donald A. Hurter, 6-46, Richard A. Snow, '48; *Ladies:* Mrs. John B. Wilbur, chairman, Mrs. E. P. Brooks,Mrs. Gordon S. Brown, Mrs. Walter H. Gale, Mrs. Ralph T. Jope, Mrs. James R. Killian, Jr., Mrs. Robert M. Kimball, Mrs. Donald W. Kitchin, Mrs. George W. McCreery, Mrs. Theodore T. Miller, Mrs. Avery H. Stanton; *Registration:* Wolcott A. Hokanson, staff, chairman, G. Edward Nealand, '32, Robert E. Hewes, '43; *Transportation:* Emmons J. Whitcomb, '11, chairman, Malcolm S. Stevens, '34.

Dollar to Doughnut

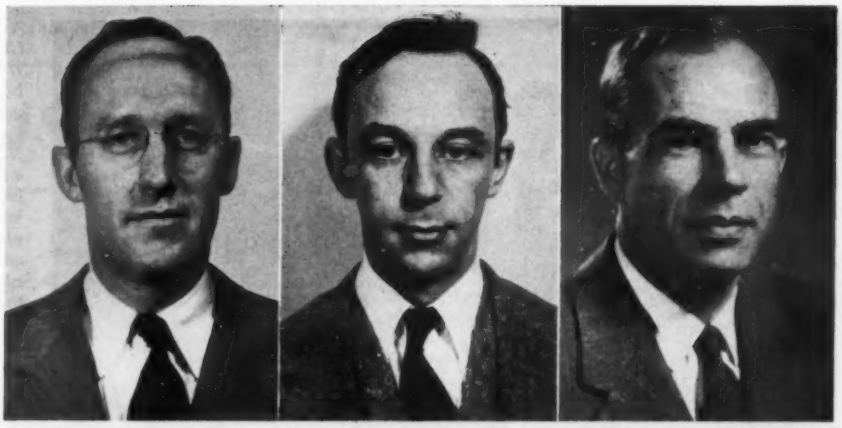
WARREN K. LEWIS, '05, who is a very much revered and almost fabulous character in the engineering world, is technically a professor emeritus in the Department of Chemical Engineering. Actually, he is, of course, very much on the job. His greatest pride is in his former students – some of whom have collected "Doc's" stories both for their own enjoyment and as an unusual method of recognizing and honoring his retirement.

"The Lewis Story," appearing under the title of *A Dollar to a Doughnut,* is a privately printed, 62-page booklet of anecdotes of the teaching and professional experience of Professor Lewis, and almost each story has an appropriate illustration by Henry B. Kane, '24, Director of the Alumni Fund. Copies of *A Dollar to a Doughnut* may be obtained for $3.00 each from Professor Thomas K. Sherwood, '24, of the Department of Chemical Engineering, M.I.T.

Although M.I.T. is known primarily for the quality of its education in science, engineering, and architecture, its Alumni frequently achieve distinction in a wide variety of other fields as well as in these three. In recognition of "outstanding services in the field of international statesmanship" members of the Class of 1907 recently presented this handsome cup to Clarence Decatur Howe, '07, Minister of Defence Production in Canada. The silver cup was designed and fashioned by Leverett H. Cutten, also of the Class of 1907.

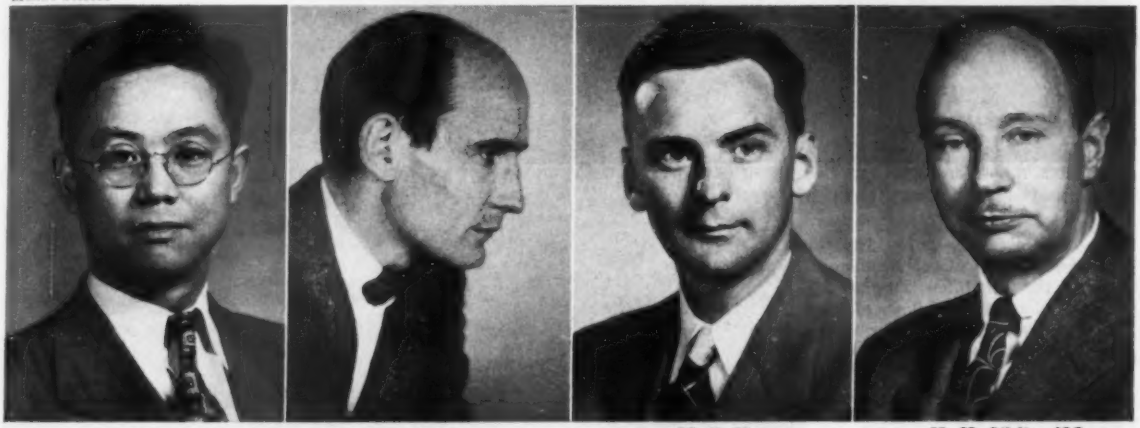
FACULTY

Promotions and Appointments



R. L. Bisplinghoff | M. Deutsch, '37 | P. M. Hurley, '40

M.I.T. Photos



C. C. Lin | E. E. Morison | M. C. Shaw | H. H. Uhlig, '32

ACCORDING to a recent announcement by James R. Killian Jr., '26, President, the Institute has acquired eight new full professors – seven by promotion and one as a new appointment. In addition, 11 assistant professors have been promoted to associate professor, and three new associate professors have been appointed to academic posts.

Members of the staff promoted to the rank of full professor are: Raymond L. Bisplinghoff, Department of Aeronautical Engineering; Patrick M. Hurley, '40, Department of Geology and Geophysics; Elting E. Morison, School of Industrial Management; Chia-Chiao Lin, Department of Mathematics; Milton C. Shaw, Department of Mechanical Engineering; Herbert H. Uhlig, '32, Department of Metallurgy; and Martin Deutsch, '37, Department of Physics.

Assistant professors promoted to the rank of associate professor are: Robert K. Mueller, '32, Department of Aeronautical Engineering; Charles N. Satterfield, '43, Department of Chemical Engineering; C. Gardner Swain, Department of Chemistry; Morris A. Adelman, Department of Economics and Social Science; Alexander Kusko, 2-44, and William K. Linvill, 6-45, both of the Department of Electrical Engineering; E. Neal Hartley, Department of English and History; William Van Alan Clark, Jr., '42, School of Industrial Management; Benjamin L. Averbach, '47, Department of Metallurgy; S. Curtis Powell, '37, Department of Naval Architecture and Marine Engineering; and Malcolm W. P. Strandberg, '48, Department of Physics.

Promotions to the rank of assistant professor are: Howard P. Jenerick, Department of Biology; James E. Boyce, and Romney Robinson, '51, both of the Department of Economics and Social Science; David J. Epstein, '49, Earl W. Keller, '49, Denis U. Noiseux, 9-46, Fazlollah M. Reza, Paul E. Stoft, '49, and Paul E. Smith, Jr., all of the Department of Electrical Engineering; Alfred D. Chandler, Jr., Thomas F. O'Dea, and Robert E. MacMaster, all of the Department of English and History; Roger M. Stinchfield, '40, Department of Food Technology; John F. Nash, Jr., Department of Mathematics; and Jack B. Chaddock, '49, Nathan H. Cook, '50, Leonard Maunder, Gerhard Reethof, '47, Robert H. Shoulberg, '48, David K. Felbeck, '49, Eugene L. Foster, and Donald R. Walker, '50, all of the Department of Mechanical Engineering.

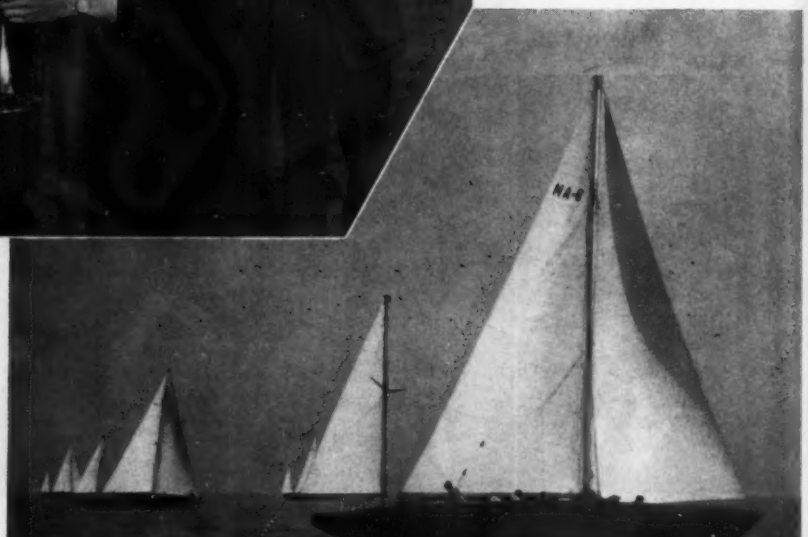
New appointments include: John M. Buchanan who will be professor and head of a new Division of Biochemistry in the Department of Biology (as already recorded in the December, 1953, issue of The Review); Walter Isard, Associate Professor in the Department of City and Regional Planning; Ithiel de Sola Pool, Associate Professor in the Department of Economics and Social Science; John M. Blum, Associate Professor in the Department of English and History; Yao T. Li, '38, Assistant Professor in the Department of Aeronautical Engineering; Robert B. Fetter and Robert H. Gregory, Assistant Professors in the School of Industrial Management; Andrew A. Root, Assistant Professor in the Department of Mechanical Engineering; Thomas B. King, Assistant Professor in the Department of Metallurgy; and Morton G. Wurtele, Assistant Professor in the Department of Meteorology.

Promotions of military personnel include those of Commander James A. Brown, '41, and Major Vincent J. Gangemi.

Official U.S. Navy Photographs

Vice-Admiral C. Turner Joy, Superintendent of the Naval Academy, awards the McMillan Trophy to Horacio Garcia, '54, skipper of the M.I.T. sailing crew which won the 1953 McMillan Cup Regatta held on April 4 and 5 at Annapolis. Looking on (left to right) are: Alain J. Deberc, '55, Edward A. Melaika, '53, Peter Felsenthal, '54, John G. Sample, '53, John H. Rieman, '54, Justin E. Kerwin, '53 (hidden by Garcia), Milton L. Almquist, Jr., '54, and an unidentified naval observer.

As the starting gun resounded across Chesapeake Bay, yawls representing 10 Eastern colleges and universities began the 1953 McMillan Cup Regatta. The annual sailing event, sponsored by the United States Naval Academy, was held on April 4 and 5 at Annapolis. An eight-man crew from M.I.T. took first place honors in the two-day race. Second place went to Harvard University, and Williams College took third place. M.I.T. sailors piloted one of the Naval Academy's 44-foot yawls shown below.



Housing Conference

HOUSING in relation to the economic problems of foreign lands was the subject of a three-day conference sponsored by the Albert Farwell Bemis Foundation at the Institute, from April 30 to May 2, 1953. The Conference on Economic Development and Housing Abroad was planned by Burnham Kelly, '41, Director of the Bemis Foundation. The M.I.T. Center for International Studies and the Departments of Architecture and of City and Regional Planning assisted in presenting the program.

The conference opened on Thursday morning with comments by Albert M. Cole, Administrator of the U.S. Housing and Home Finance Agency. As the principal speaker at the conference dinner on Thursday, April 30, Sir Percy C. Spender, Australian Ambassador to the United States, discussed economic developments in south and southeast Asia.

In addition, nearly 40 other experts from throughout the United States and several foreign countries participated in conference sessions. At least 150 architects and foreign aid and housing specialists attended the three-day program.

Commenting on plans for the conference, Mr. Kelly noted that:

. . . proposals for international development tend to be formulated by economic planners, and the importance of the role to be played by physical planners is often overlooked. Furthermore, the training of designers should be greatly improved by confronting them with the unfamiliar problems of the resources, desires, and needs of another culture.

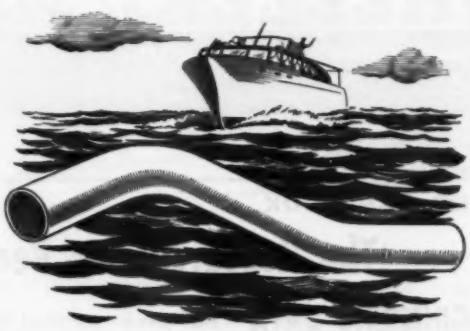
Great sophistication is often required to work with limited resources and objectives, and the habit of looking behind appearances for facts is more easily developed in unfamiliar surroundings. The conference also continues the interest of the Bemis Foundation in the design implications of production of houses in large quantities. The contribution of a trained designer able to make appropriate use of local skills and resources, becomes a significant part of economic development plans.

The conference reflected the desire of numerous students in this country to do useful work abroad. Many students in the School of Architecture and Planning who come from abroad and who desire training to deal with unusual problems in their native lands found the conference of unusual educational value.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Here is another example of thorough collaboration between a supplier and a customer, and the values obtained thereby. The case involves the production and bending of copper tube whose wall is rather thin relative to its diameter. The tube is formed into exhausts for fine pleasure craft, sailed the country over in both fresh and salt water. The boat builder specifies copper for this application, because of its corrosion resistance, which means long life, economy, and the satisfaction of yachtsmen. However, the tube is not bent at the shipyard; an outside bending firm applies its skill to this exacting task.



• When Revere suggested that it was a good source of supply for copper tube, we were promptly turned over to the fabricator of exhausts, with the statement that he was the one to be satisfied, that his high requirements had to be met, and that the boat company would merely inspect exhausts to make sure that they met specifications, including not only dimensions and curvatures, but the complete absence of cracks and wrinkles where the tube is bent.

• This at first glance seemed to be an unusual problem. The exhausts run in size from two to three and a half inches, outside diameter, with a wall of .049 inch. That wall was dictated by the desire to save weight. If the exhausts had been made of rustable materials, naturally they would have been much thicker and heavier. Revere's Technical Advisory Service visited the tube bender's plant and studied production methods. Complete details were discussed with the Methods Department at the Revere Mill which would be responsible for quality. Everybody realized that here was a challenge. The mill, fortified by exact knowledge of what was needed, set up special standards of control over roundness, concentricity and temper.

• Production tube worked perfectly from the very beginning. No wrinkling or tearing has been encountered by the firm which bends the tube. This is a tribute to their skill, as well as ours. The happy people who enjoy life afloat in the boats containing these copper exhausts have no idea of the care and attention given by so many people to a part of which they may be entirely unconcious, but which serves in its own way to protect their pleasure and their investment in carefree yachting.

• Perhaps you, too, have problems which can be solved successfully by complete collaboration with your suppliers. If you give them, as this tube bending company gave us, every opportunity to study production methods and end uses, perhaps they may be able to find ways and means to lessen rejects, speed up production, save you money. Don't hesitate to ask. After all, in every bill there is an unseen item for the cost of the knowledge, experience and skill necessary to produce fine materials. You might as well obtain the plus values that lie behind the gallons or pounds or feet or tons of what you buy.

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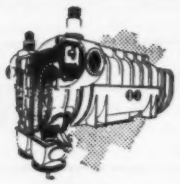

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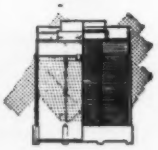

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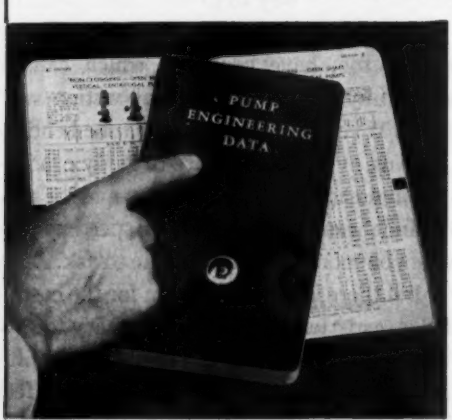

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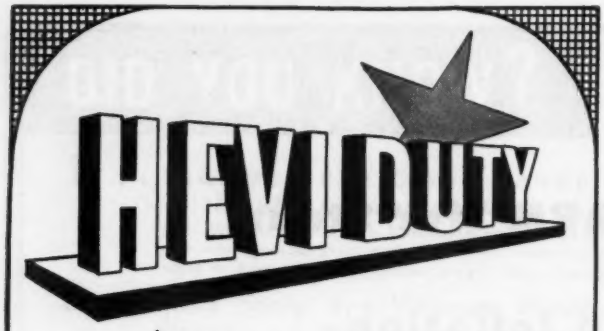

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MECHANICAL ENGINEERING

(*Continued from page 432*)

The principle that anything significant to life itself is worthy of serious study has recently had interesting applications within the field of mechanical engineering. The leaders in pure science, physics, chemistry, and even mathematics, have been enticed into ever more exotic realms of research, leaving fallow large regions of the older topics of study. Some of the neglected fields, such as dry friction, surface phenomena of metals, lubrication, metal cutting, physical properties of matter in the solid state, combustion, and corrosion, for example, have already been re-worked in recent years and have yielded rich returns in utility and intellectual satisfaction.

Another example of the same principle occurs in the field of design. It is only in our own generation that the true significance of the design function has come to be fully appreciated in machinery developments. At the dawn of the technological epoch, the great designers were creative in the true sense of the word. As industrial processes became more complex, the function of design was fragmented into unrelated operations, each of which tended to become a clerical routine. In recent years, the subject of Industrial Design has gained recognition as a means of coalescing and fusing together all significant design elements having to do with the planning, production, sale, use, and acceptance of a product. Certain domains of industrial design – in which art and architecture play dominating roles – may fall outside the scope of technological education. Nevertheless, a promising venture has taken place and has inspired a few students in engineering with a new perspective of the design function.

The new sense of belonging to the industrial world, which has come about as the result of developments such as those enumerated above, has also brought impatience and dissatisfaction with some of the outmoded forms of engineering education. Perhaps some of the worst offences were committed in stereotyped unimaginative laboratory exercises which outlived their former usefulness and today seldom represent noteworthy intellectual experiences.

Although some elements of the old-fashionel laboratory instruction may have to remain, interesting and valuable experiences have been obtained by a modified approach to the concept of "learning by doing." One very promising approach is that which permits students to attack mature problems in teams, working under assigned leaders chosen from among themselves and supervised by members of the staff. Certain industries have co-operated in these programs without expectation of return on their modest investments, except the hope of interesting students as potential employees. The scheme has obvious limitations and requires instructors having special qualifications in psychology as well as in teaching and technical competence. But it has already done much to give vitality to laboratory instruction, and the students have the thrill of participating in a stimulating experience. It represents a workable

(*Concluded on page 444*)

ENGINEERS WANTED!

Grinnell Gets $230,000,000 Contract at Atom Plant

Grinnell Corp. today was awarded a major sub-contract on the Portsmouth, Ohio, area atomic plant that is estimated at $230,000,000.

It was awarded by Peter Kiewit Sons' Co., A-plant prime contractor, and is for mechanical construction on the gaseous diffusion uranium separation plant. It includes process piping, auxiliary piping, instrumentation, equipment installation, testing and other work of related nature.

Grinnell management believes it is the largest mechanical contract ever let.

"We consider it quite an honor to be selected to do the job." James D. Fleming, president, said.

"It is too early to say what effect the providing of materials will have on the company's operations here," he added.

The award to Grinnell followed several months of study by officials of the Kiewit Co. with the Atomic Energy Commission.

Factors in the selection of Grinnell Corp. included its background and experience in large-scale mechanical construction, its manufacturing techniques, availability of top level management and technical personnel, the status of present commitments on large-scale jobs under construction and the interest of the company in accepting the Portsmouth job.

On the basis of these studies, it was concluded that Grinnell was best qualified and best able to take on the project.

Kenneth A. Dunbar, Portsmouth area manager for the Atomic Energy Commission, said: "We feel we are fortunate in obtaining the Grinnell Corp. for this job. We put in a great deal of time in search for the right concern and are confident we have obtained the best available."

Grinnell Corp. already has established offices in Portsmouth.

S. F. Mathes, a Brown graduate, who has been affiliated with Grinnell for 13 years, will be the resident manager for Grinnell.

Hugh Welshman, manager of the local company's industrial pipe division, is the co-sponsor for the job. He will be the home office official who will be responsible for the necessary co-ordination and management policy for the Portsmouth project.

Grinnell Corp. currently is working on the Electric Energy, Inc., steam plant at Joppa, Ill., which will supply part of the power for the AEC plant at Paducah.

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If you are a graduate engineer, there may be an unusual opportunity for you with Grinnell Corporation at Portsmouth, Ohio.

Grinnell needs experienced piping and process equipment engineers.

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Grinnell is also America's #1 manufacturer of pipe hangers and supports, including constant supports for main steam lines operating at 1,050 F.

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Grinnell Thermolier Unit Heaters, Welding Fittings and its many other piping products have been well-known for many years.

Grinnell operates throughout the United States and Canada, with 8 manufacturing plants, 33 branch warehouses and a multitude of sales offices. It is a company with over 100 years of experience in the piping field behind it, with a tremendous present growth, and with an exciting future for engineers who become piping specialists with Grinnell.

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MECHANICAL ENGINEERING

(Concluded from page 442)

counterpart on the undergraduate level to sponsored research on the graduate level.

As a result of closer relations between the students and the staff, concurrently with developments in academic and professional directions, the Department has become a more closely knit organization, and as a consequence, certain joint projects of mutual interest are now well advanced in the planning stage and will be executed as soon as the necessary funds are available. One of these projects represents a memorial to the late Professor Edward F. Miller, '86, who for many years guided the destiny of the Department of Mechanical Engineering. This will take the form of a room established in his honor and suitable for small receptions, seminars, and similar functions. Another somewhat similar project involves the establishment of a Commons Room in the Department. This is to be the center of student-staff social relations and is to include certain recreational facilities, as well as the headquarters of the professional societies now affiliated with Course II. The Department Visiting Committee of 1952-1953 has kindly consented to sponsor both of these undertakings. The Department of Mechanical Engineering is making every possible effort to encourage and provide a well-rounded education through contacts both within and outside the classroom.

Conclusion

The need for technically trained personnel to discharge their professional responsibilities, not only as competent engineers or scientists, but also as well-rounded, cultured members of a highly complex society, is more urgent today than ever before. It is no longer possible to achieve the goal of adequate education by the outmoded methods of yesteryear, no matter how well such methods may have served the needs of our grandfathers or our fathers. Today, the education of the professional man must be closely integrated with life itself; it must draw its stimulation from all fields of human endeavor and be of the highest possible caliber. The professional man's education should also inspire him to expand beyond the restrictions of narrow, technical accomplishment and to make his contributions to society in the many ways by which he is especially qualified. This the Department of Mechanical Engineering aims to accomplish.

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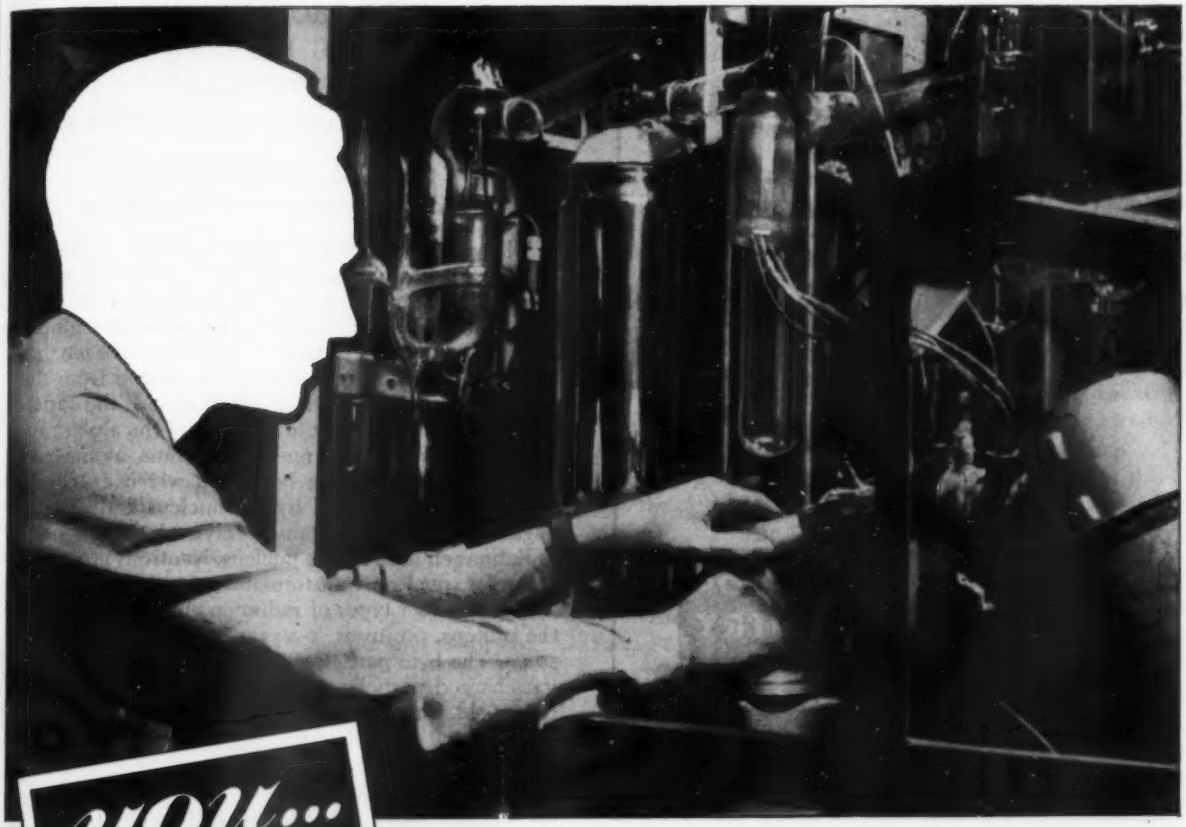

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THE PROBLEM OF IONIZING RADIATION

(*Continued from page 434*)

velopment of modern nuclear physics and the use of radioactive isotopes.

Radioactive Isotopes — Their Nature

All radioisotopes, including those found in nature and those artificially produced, have a common property in that they are unstable, undergoing a constant disintegration and change into other unstable isotopes and finally to stable isotopes. The radioactive emanations due to disintegration may be emitted from the unstable atoms or by atoms which absorb the radiation. At present the most important are the alpha rays or particles which are nuclei of helium atoms and carry a positive charge; beta rays which are high-speed electrons emitted by the nucleus and carry a negative charge; and gamma rays, electromagnetic radiations emitted by the nucleus. Neutrons are products of a nuclear transformation and are unstable. There are other types of radiation emanated, namely the protons, positrons, x-rays, neutrons, mesons, and so on. The beta particles and the alpha particles, being charged particles, are both deflected in an electrical field. Gamma rays are found to be unaffected by the presence of an electrical field and are observed to be the most penetrating of the three. The effective range of alpha particles in air is approximately 10 centimeters, while that of beta particles and gamma rays is dependent upon the energy. Thus, these rays may travel several meters in air before attenuation. Normally the alpha particles cannot penetrate through the dead layer of the surface skin. The beta particles of 1,000,000 electron-volts maximum energy will be practically entirely absorbed in the first six millimeters of tissue. Gamma rays of the same energy may penetrate to a much greater depth.

Since radioactive materials have the ability to cause ionization directly or by means of secondary radiation, this property can be used for their detection and measurement. In this way gamma rays are similar to x-rays which also produce ionization by means of secondary radiation. Similarly, neutrons produce no ionization directly but they eject protons from material rich in hydrogen. The protons ionize the gas in proportion to the number of neutrons that produces them. The arbitrary unit of measurement, the roent-

(*Continued on page 448*)

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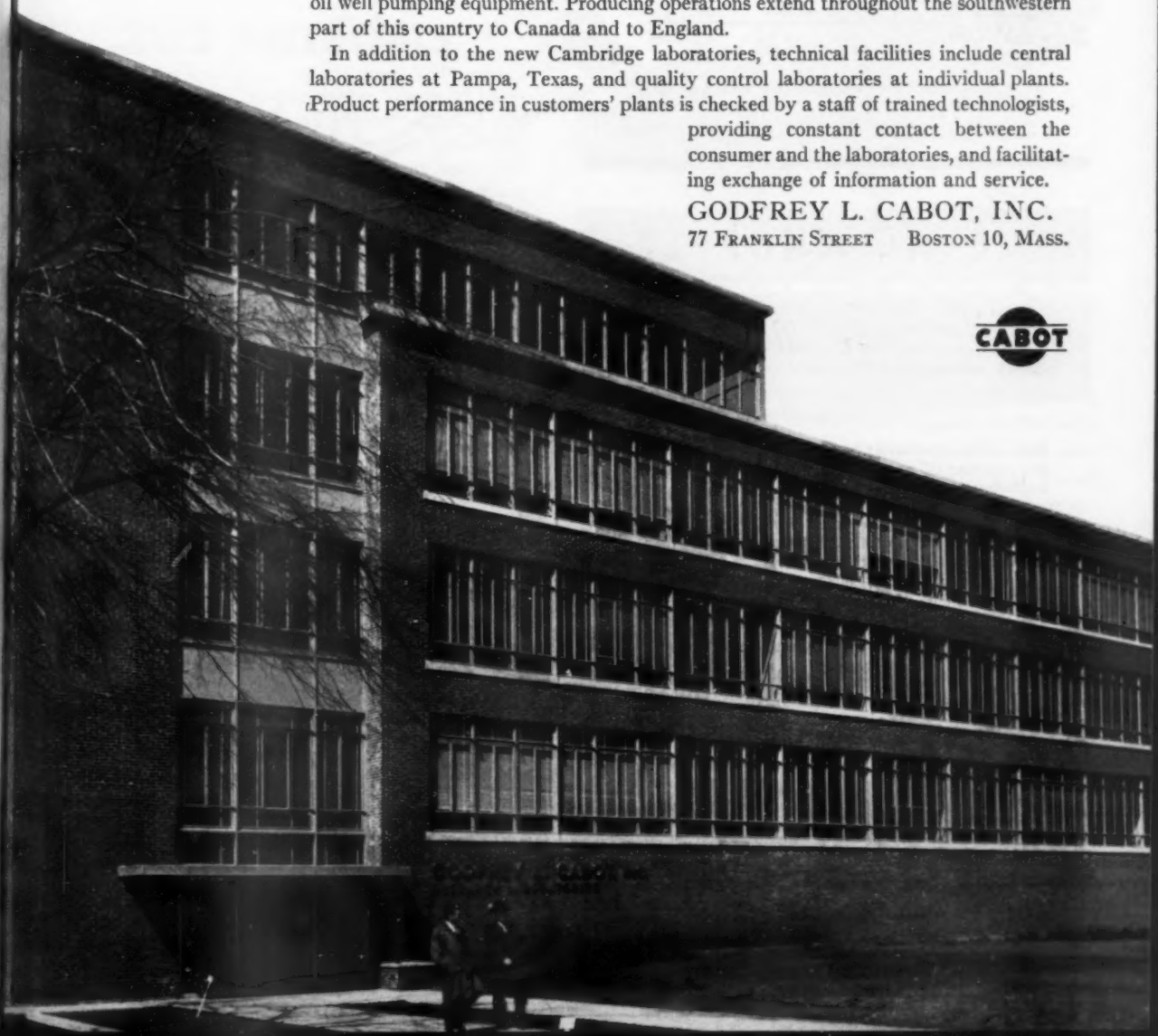

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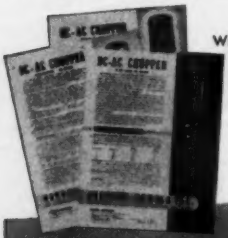

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THE PROBLEM OF IONIZING RADIATION

(*Continued from page 446*)

gen, is used to express the resulting ionization caused by the radioactive emanations. The activity of the radioactive material also may be expressed by the amount of disintegration the material undergoes in a given period of time.

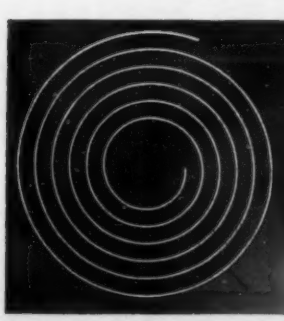
Another arbitrary unit of measurement, named in honor of the Curies, is primarily used to express the intensity of the radiation based on the disintegration of its atoms, and may be applied to all radioactive materials to express the amount of disintegration. The unit, one curie, has been defined as that activity due to 37 billion disintegrations per second. Since the various radioactive substances disintegrate at different but definite rates, a convenient expression termed the "half life" is used to designate the time in which radioactive substances will disintegrate to 50 per cent of that which existed at any given time. For instance, the half life of radium is approximately 1,600 years. In 1,600 years, 50 per cent of the original amount of radium will remain. Likewise, the half life of radioactive phosphorus is 14.3 days.

Approximately 250 isotopes occur in nature, while approximately 800 artificially produced isotopes are known. The term isotope is derived from the Greek word "isotopos" which means "same place." In other words, an isotope of an element occupies the same position in the periodic table as the element, and has the same chemical properties but different physical property, namely, stability. These isotopes have the same atomic number as the element but a different mass number. The isotopes usually cannot be separated chemically, but some method which makes use of various physical properties is used. An example would be the separation of the isotopes by means of an electrical field or by diffusion.

Radioactive Isotopes — The Injury Experience

The first recorded injuries were due to lack of knowledge, improper handling, and misuse of the natural radioactive elements uranium, radium, and mesothorium. Most of the early cases reported, involving the use of these substances, consisted of blood changes and burns. There were several deaths, particularly among research workers. In 1923–1924, the first cases of a new type of radiation injury due to the use of

(*Continued on page 450*)



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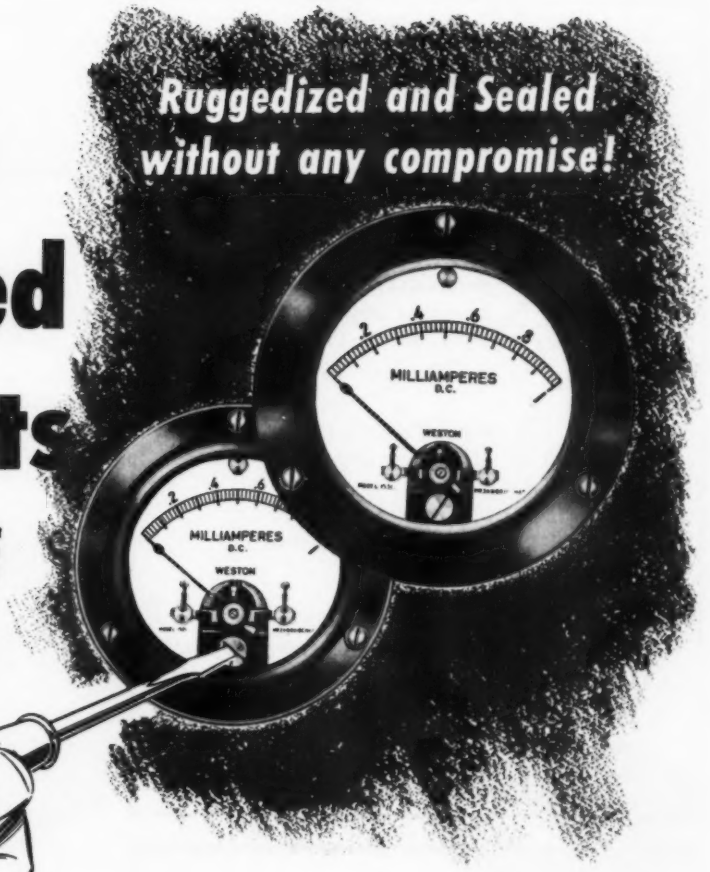

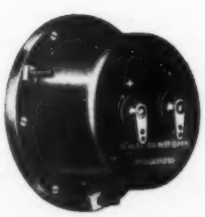

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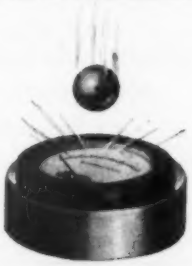

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THE PROBLEM OF IONIZING RADIATION

(*Continued from page 448*)

radium and mesothorium in luminous paint became known. This involved the destruction of the bones of the jaw, followed by suppuration which was at first thought to be the phossy-jaw injury seen among match workers. Most of those affected were women who had worked with the luminous paint while applying this paint to figures on watch, clock, and instrument dials by means of a camel's hair brush. The women habitually shaped and pointed the brushes with the lips and tongue. This unsafe working practice resulted in the ingestion of small quantities of the radioactive paint. In Europe, where a similar operation was carried on, a pointed stylus was used instead of the brush, and there were very few cases of radium poisoning since it was not necessary to shape the tip of the brush. Examination of the people affected showed that, in addition to the bone injury, there were blood changes and cancer growths. By 1934, death occurred to 23 of these women. The inventor of the painting formula used by the particular factory where these cases appeared, died of aplastic anemia. Due to the relatively high frequency of radium-poisoning cases, a special study was made in this country. The investigation resulted in the development of a code for the safe handling of radium compounds. At present, there are three companies in the Commonwealth of Massachusetts engaged in the use of radioactive luminous compounds. These companies are very cooperative and have complied with all the regulations of the state code, which stipulates engineering and medical controls as well as safe working practices.

The intense ionization of air produced by alpha particles, particularly from radium, has found an important use in industry because of its effectiveness in eliminating static electricity from moving paper, textiles, plastic sheeting, and so on. Since the half life of radium is about 1,600 years, its action may be considered permanent as far as industrial installation is concerned. To date the Division of Occupational Hygiene has investigated the use of over 275 units in some 85 industrial establishments in the Commonwealth. The instrument used for eliminating static is known as the Ionotron Static Eliminator and consists of a radium salt uniformly distributed throughout an extremely thin metallic foil (usually gold) welded to a heavy metallic nonradioactive backing. The metallic

(*Continued on page 452*)

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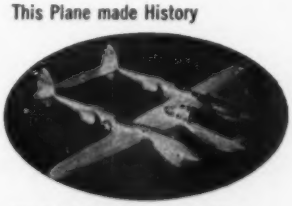

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THE PROBLEM OF IONIZING RADIATION

(*Continued from page 450*)

foil serves as a mechanical bonding medium for the radioactive material and also as a seal to prevent the escape of radon gas. The alpha radiation is emitted directionally, creating an ionized zone in the region of the electrostatic charge, so that it is conducted away from the material being processed. The effective range of alpha rays is less than three inches and, as previously stated, will not penetrate the skin to any great extent. However, the static eliminator produces radiations such as beta and gamma rays which may cause injury to an employee if precautions are not taken. The Massachusetts Division of Occupational Hygiene has an arrangement with the manufacturer of these units and is notified of any new installations in the Commonwealth. When notified, a survey is made by the Division to determine whether or not the potential hazard is satisfactorily controlled.

The use of the artificial radioisotopes has increased greatly in the past five years since their release by the Atomic Energy Commission. The Commonwealth of Massachusetts is the second largest user of radioisotopes in the country. At the request of the Atomic Energy Commission, a joint survey was conducted by the Division of Sanitary Engineering, State Department of Public Health, and the Division of Occupational Hygiene, State Department of Labor and Industries. There are approximately 40 users of radioisotopes in Massachusetts. Most of the users are hospitals and educational institutions. There are very few industrial establishments using radioisotopes at present. A small amount of radioisotopes is produced by the cyclotrons at Harvard University and at M.I.T. A great amount of research is being done with radioisotopes, particularly in educational institutions and hospitals. Usually the amounts handled are tracer quantities and offer no serious hazards to those handling the materials. Some of the hospitals use larger quantities in therapeutic work. In industry one company in Massachusetts is the bulk receiver of various radioisotopes and subdivides the radioactive material received from Oak Ridge into desired quantities as specified by the purchasers. Occasionally a high intensity of Co^{60} is used as a reference source in the manufacture of various scientific instruments. Radium can be used for this job also but is much more expensive than the Co^{60} in the same intensity.

At least 95 per cent of the radioisotopes are handled in laboratories, only a few of which have been designed to handle high-intensity materials. Special safety programs and safeguards should be utilized, consisting of special hoods, remote handling devices, and suitable protective clothing, and so on.‡ Arrangements must be made for the proper disposal of the waste by storage, burial in the ground, or dumping at sea. In the future it is expected that many more industrial establishments will utilize radioisotopes in research, as reference sources and in the products

(*Concluded on page 454*)

‡ The safety program in force at M.I.T. is described by Harriet L. Hardy, "An M.I.T. Enterprise in Occupational Health," The Technology Review, **55**:315 (April, 1953).

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THE PROBLEM OF IONIZING RADIATION

(*Concluded from page 452*)

manufactured. To date some plants have produced thickness gauges using radioactive sources, particularly those that emit beta rays.

Since the discovery of ionizing radiation some 50 years ago, the various ways to which this phenomenon has been put to use have resulted in not only great benefits to society, but have also brought with it injury and death. The unfortunate experiences of those who have suffered have served as a fountain of experience for the promulgation of controls necessary for the proper guidance of those who, in the future, may be exposed to this serious hazard. The injury experience can be reduced to a minimum, as was accomplished by the Atomic Energy Commission while engaged in the handling and use of materials emanating very high intensities of ionizing radiation.

References

The Story of X-Ray (Schenectady: General Electric Company, 1945).

Hoffman, Frederick L., "Radium (Mesothorium) Necrosis," *Journal of the American Medical Association*, 83:961–965 (September 26, 1925).

X-Rays, Bulletin No. 609, November, 1951 (Massachusetts Department of Labor and Industries, Division of Occupational Hygiene).

"Survey of Radioisotope Users in Massachusetts," *New England Journal of Medicine*, 244:159 (January 25, 1951, No. 4).

Measurement of Radioactivity, Circular 476, October 15, 1949 (U.S. Department of Commerce, National Bureau of Standards).

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